



TEACH YOURSELF BOOKS

Patrick Meredith

LEARNING, REMEMBERING & KNOWING

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LEARNING REMEMBERING AND KNOWING

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To
SIR RUSSELL BRAIN
in token of valued conversations on
the "schema" and other matters

INTRODUCTION

EACH of these three words “learning”, “remembering” and “knowing” can mean very different things and this is rather confusing. It is not a good plan to start a book by confusing the reader and so I shall give one meaning only for each word and stick to it. Towards the end of the book there will be an opportunity to glance at some of the other meanings.

In the “Teach Yourself” series the general assumption is that you can teach yourself from books. I shall therefore define “knowing” as follows: To “know” the subject matter of a book is to be in a state of mind in which, given time, you can answer any reasonable question about the contents of the book. I shall say more later about “state of mind” and “reasonable”.

“Remembering” can be defined thus: To “remember” an item of knowledge is to be in a state of mind in which you can immediately reproduce the item if required to do so.

“Learning” will be taken in two senses: *learning for*

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remembering and *learning for knowing*. To “learn for remembering” is to read in such a way that the content can be remembered whenever required. And to learn for knowing is to read in such a way that the content will be both understood and retained.

In this last definition two new ideas come out, namely *understanding* and *retaining*. You must have had the common experience of having a name, for instance, “on the tip of your tongue” but failing to recall it. A few moments later it “comes” to you. So it was “there” all the time. Where? You had succeeded in *retaining* it but you could not *recall* it. *Remembering* requires both retaining and recalling. To learn for remembering therefore requires you to read in such a way that you will both *retain* and *recall* what you read whenever you wish. An element of drill is involved in this. You must drill yourself to retain by repeated *readings* if necessary. And you must drill yourself to recall by repeated *testings*.

Similarly in *knowing* we need two processes: *understanding* and *retaining*. These definitions imply that you can remember without always understanding and this is indeed the case. Also that you can know without always remembering, and this likewise is the case. But the important words “given time” indicate that “knowing” means “being able to remember *sooner or later* something you have already understood”.

Our mind is a busy workshop and cannot keep all its equipment permanently out on the bench ready for immediate use. But in a well-organised workshop everything is well-stored. If you need something at short notice you may not have it instantly to hand but you can climb a ladder and fetch it from the top shelf if necessary.

The "ladders of the mind" are the *clues* which we use to track down items of knowledge which cannot be immediately remembered. The "organisation" and the "shelves" will form important topics in our later discussion. The work that goes on at the bench must also be considered. For here the items which go into the store may be taken to pieces and reassembled, and a sketch may be made of their internal construction. Both the item and the sketch can then go into the store. In the mind it is the stored items which constitute our *memory* and it is the stored sketches which constitute our *understanding*. Thus *reading for understanding* means taking items of knowledge to pieces as we read them and seeing how the pieces are connected.

A book is arranged to start at the beginning of the first chapter and to finish at the end of the last chapter. This seems natural enough but in fact it is purely an arrangement to suit authors, printers and booksellers. It does not at all correspond to the needs of the reader's mind. For a piece of *understood knowledge* is not a mere succession of ideas. It is a pattern of connected ideas. Some of the ideas in a book, though connected, may occur on pages which are widely separated. If books were designed to meet the needs of the reader they would be printed on one side of the paper only and not bound. They would be loose-leaf books. And the reader should have a large table on which he could spread out the leaves and *see* the connections of meaning. Of course there are many practical objections to such a method of printing but we must ask how can the reader overcome the handicaps which the present design of books imposes on him?

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This leads us to consider the reader's job. My main object in this book is to show the solitary student what his job is. For in order to become an effective reader you have to learn how to learn, to learn how to remember and to learn how to know. This is not a passive process but a real job of work. For the serious student it can be a very satisfying job and can take him a long way in navigating the seas of knowledge.

To each of these three processes, learning, remembering, and knowing, there are four possible approaches. These are:

- (1) the philosopher's approach
- (2) the psychologist's approach
- (3) the teacher's approach
- (4) the learner's approach

The solitary learner should aim at mastering all four approaches. He must be his own philosopher, his own psychologist and his own teacher.

As a philosopher he will want to know the meanings of these important words *learning*, *remembering* and *knowing*, or rather to decide what meanings they are to have for him. For they have many meanings. He needs to clarify them, to see their relations one to another and also to his objective.

As a psychologist he needs to observe himself at work (and others too if possible) and to find out what sorts of processes are going on when he is coming to grips with new knowledge. It is a very variable process and he needs to grasp the nature of the variables which control his efficiency as a learner. He may discover that many

of his assumptions and preconceptions about the nature of learning are unsound. He must become a critic of his own methods and an experimenter in the discovery of better methods. He cannot expect the professional psychologist to tell him what is best *for him* because every individual is different. The psychologist can tell him what the variables are but not how they combine in his particular case.

As a teacher he is, of course, in an anomalous position. The ordinary teacher is teaching what he knows. The self-teacher would seem to be a contradiction. But the → contradiction is more apparent than real. It rests on the mistaken notion that the teacher has something which he is passing on to the learner. This is only superficially true. The learner is not a passive recipient. He already has a certain store of knowledge and a certain vocabulary. The job of the teacher is to set the learner's vocabulary to work on the existing store so as to make it grow. He does not simply pack new things into the store. The solitary learner has to find out how to do this for himself, with the help of books. He uses his vocabulary to ask questions and uses the books to find the answers.

Thus learning how to learn means becoming your own philosopher, your own psychologist and your own teacher. You will then be a well-established learner and the world will be at your feet.

ONE

THE MIND

THOSE who identify rationalism with an undue respect for verbal logic generally identify freedom of thought with permission to persist in discussing age-old conundrums without guidance of near information.

*LANCELOT HOGBEN, *Dangerous Thoughts**

ONE

THE MIND

ALTHOUGH the word "mind" has given rise to endless controversy among philosophers and psychologists, many of whom would like to abolish it from the dictionary, most of us obstinately go on using it. It is short and familiar and its many meanings can be otherwise expressed only by cumbersome and abstract terms which then introduce new difficulties. But it is advisable, in any particular context, to narrow down its meaning so as to avoid confusion.

"Mind" has often been contrasted with "matter" in such a way as to suggest that the two are somehow opposed and incompatible. And then you get a knock on the head and all evidence of "mind" vanishes, at any rate for some time. It seems very difficult to detach the mind from the brain, and all the biological, surgical and pharmacological evidence points to a very close connection. There is a lot to be said for keeping the word "soul" to stand for what many believe to be the imperishable essence of a man which is supposed to persist apart

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from the body, and to reserve the more prosaic word "mind" for the basis of all those experiences and phenomena which are clearly associated with the brain.

Can we now put forward any reasonably clear picture of this "basis" of mental phenomena? The physicists have succeeded remarkably well, with the atomic theory, in giving a clear and detailed picture of the basis of such material phenomena as chemical action, magnetism, the behaviour of gases and so on. Where has psychology got to in its theories of "mind"? Are there any ultimate units of mind akin to the atoms of matter?

At one time it was thought that mind could indeed be analysed into discrete bits. These bits were identified as elementary sensations. These were thought to combine together to form compound experiences by analogy with the way atoms of matter combine to form molecular compounds. But this view led to too many difficulties and was finally abandoned. Nevertheless the search for basic units of mind has gone on and will doubtless continue, for it is the aim of science to discover ultimate units. We must beware, however, of supposing that there must be any close analogy between the units of quite different sciences. For example the success of the atomic theory in physics might lead us to suppose that the ultimate units of geometry must be *points*. It would be more correct to regard *operations* as the ultimate units of geometry.

There have been many conflicting tendencies in psychology in its search for ultimate units and here we can only indicate what seems to be the most promising concept which is current today. It is known as the

schema. It is not an easy concept and if I try to make it concrete it will be at the cost of over-simplification but even so it may be better than a meaningless abstraction. The following conversation between Hamlet and Polonius shows that Shakespeare had at any rate an intuitive grasp of the notion:

Hamlet: Do you see yonder cloud that's almost in shape of a camel?

Polonius: By the mass, and 'tis like a camel, indeed.

Hamlet: Methinks it is like a weasel.

Polonius: It is backed like a weasel.

Hamlet: Or like a whale?

Polonius: Very like a whale.

Now the whale, the camel, etc., were not in the sky. The clouds are mere aggregates of water-drops. The whale, etc., were in the minds of Hamlet and Polonius. But they could both *see* the cloud. Thus an image of the cloud was also in their minds. Moreover they knew it to be a cloud. Yet they could "see" animals in it. This is the important fact about mental phenomena. The physical cloud in the sky is just itself, made of water-drops. The mental cloud is a multiplicity. To begin with it is a pattern of brain-processes, just as physical as the water-drops. But it is experienced (i) as a cloud, (ii) as a whale, (iii) as a camel and so on. We cannot dismiss these as "illusions" for it is just the occurrence of such illusions that we seek to explain—besides why is it illusory to see the thing as a whale but not illusory to see it as a cloud? And how did Hamlet *know* it was "really" a cloud?

For the moment we need not concern ourselves with

these last questions. What we have to grasp is that there are patterns of brain-activity of different kinds. There are patterns which result directly from processes such as seeing, hearing, etc., e.g. that which is experienced as the shape of the cloud (but not yet identified as such). And there are patterns which result in *interpretations* such as "cloud", "whale", "camel", etc. The image is fairly steady and durable. The interpretations can shift very rapidly. These interpretations are called "schemas" (or more pedantically "schemata").

At one time "mind" used to be identified with "consciousness". But "consciousness" simply refers to the stream of changing experiences. It will simplify our explanations if we regard consciousness as a *property* of mind rather than as mind itself. If we define "mind" as the totality of schemas in a single brain and regard "consciousness" as a certain transitory state which any schema, or group of schemas, can assume, we can give a more consistent account of our experiences and interpretations.

Before going further we should try to face what is an almost inevitable difficulty for anyone approaching the study of mind for the first time. It is the tendency to get things the wrong way round. As a psychologist I am constantly encountering this tendency in friends and acquaintances. They think there is something inevitably "queer" about psychology and this feeling of queerness usually boils down to a quite mistaken belief that the psychologist first looks into his own mind and then interprets other people's minds by what he has found in his own. This is what I mean by "getting things the wrong way round". He is far more likely to find out

about how his own mind works by looking at other people's. For although looking inwards (or "introspecting" as it is called), is not entirely ruled out, nowadays most psychologists would agree that it is one of the most unreliable methods of getting any precise information. And so they prefer objective methods. Since they cannot directly look into the mental processes of another person they observe his visible behaviour and then try to give theoretical interpretations of what lies behind this behaviour. This is no more queer than the method of the doctor who observes signs, and records symptoms, and diagnoses the inner states responsible for them. He may never have had the disease himself but he can nevertheless identify it. Similarly the psychologist has to be prepared to observe and make inferences about all kinds of processes in other people, whether or not they correspond with anything in his own experience.

We know very little about the patterns of brain-activity which provide our schemas, nor do we need to know as far as psychology is concerned—these patterns are the concern of the neuro-physiologists. What concerns psychology is the interpretation for which each schema is responsible. For it is these interpretations which give meaning to all our experiences. By means of language we can often find words for these interpretations (though language is not inevitably associated with them). It is through language that we get evidence of schemas in other people's minds.

To speak of schemas *in* people's minds is rather loose unless we clarify it. It is not like speaking of potatoes in a saucepan. A closer analogy would be currents in an ocean, the ocean consisting of the totality of currents.

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Even this is misleading, however, for currents cannot intersect, whereas the characteristic feature of the schemas is that they overlap and merge into one another in rather baffling ways, and are yet capable of being separately apprehended. You can think of Parliament, of Government and Opposition, of Lords and Commons, as three separate ideas and yet appreciate their essential identity. In fact what makes "mind" so difficult to explain is our failure to find any satisfactory material analogy for it. But this is not to say that it has no material basis. Its basis is the activity of thousands of millions of brain-cells. Perhaps the music of an orchestra would be a nearer analogy. For this has a total pattern which is not located in any particular instruments and which yet depends on the playing of those instruments. And in that pattern you can often discern several themes interwoven with each other and many overtones. But we must not push this analogy too far either.

What we *can* say assuredly, on the basis of the objective wave-recordings of the electroencephalograph (which picks up the "music" of the brain-cells and translates it into inkmarks on paper) is that our thoughts and conditions go hand in hand with the electrical discharges of our brain-cells in patterns of immense complexity. It will save some confusion if we observe that there are three distinct points of view, giving us three distinct stories about what is going on. In a typical experiment in electroencephalography we have

- (1) the subjective experiences of the person whose brain we are studying (known as the "subject"), on which he can give a verbal report afterwards;

- (2) the physical record on paper, which can be analysed into groups of frequencies for the mathematician and physicist to deal with;
- (3) the account given by the psychologist of the task presented to the subject, e.g. a bit of mental arithmetic.

We could add a fourth, viz. the story told by the neuro-physiologist concerning the working of the brain-cells, if they knew enough about it.

The problem of the relation between mind and body is the problem of reconciling these four quite different stories about one and the same actual event, viz. something going on inside the subject. We are a very long way from blending those four stories into a single coherent account. But obviously the more accurately each separate story is told the more possible it will be to find how they tie up.

For the moment we are concerned with the psychologist's story. Notice that, contrary to common belief, he is not really concerned with trying to describe the subject's *experience*. For even the subject himself is often very vague and erratic about this, and if he cannot tell us precisely what went on *inside*, how can anyone *outside* presume to know? Now it is precisely over this question that a good deal of confusion exists, even, regrettably, among psychologists. For it is the business of the psychologist neither to describe the subject's experiences nor to describe the physiological processes in his brain but *to describe how his mind was working*. Some psychologists may prefer to say that they are

seeking to describe "inner behaviour" but the difference is one of terminology.

The crux of the matter is that for the psychologist the basic units of explanation are neither sensations nor nerve impulses but *schemas*. As the body is built of cells the mind is built of schemas. The body has many different types of cells and the mind has many different types of schema. Body-cells develop and interact in various ways and schemas do the same—they have a kind of life. Body-cells are sometimes quiescent and sometimes active, and the same is true of schemas. Some body-cells are much more fixed and permanent than others—blood-cells, for example, are continually being manufactured and destroyed. The schemas likewise vary in durability. The body-cells are organised and controlled by the working of the whole body, i.e. they form a system. The schemas form the system of the mind, an organisation. The body-cells depend on a continual intake of nutrition. The schemas depend on an intake of *stimulation*. The need may not be so regular and insistent as the body's need for food, but any prolonged cutting off of stimulation can produce serious mental disturbance.

These are only points of comparison. They do not serve to define the schema, still less to explain it. They merely help to give some substance to the notion. In the last resort every schema is an individual pattern in an individual brain. But in any science we have to classify things in groups. Biology does not deal with individual dogs like Spotty or individual cats like Tibby. It deals with *species* or types. In psychology, therefore, we have to ascertain what are the principal types of schemas. Now there is a certain subtlety here which could land us in

difficulties. Each schema is the basis of part of the total *knowledge* of the individual person. We know our world through our *schemas*. The world is endlessly changing and variegated. No two things or events are ever quite identical. But the lesson which all animals, including ourselves, have to learn is that causes which are alike *in certain respects* produce similar effects. Flames differ widely in shape, size, colour, etc., but *all flames burn*. We all have to learn what to expect from our surroundings. This requires us to learn to recognise recurring features in our surroundings, features which *matter* to us in some way. We have to learn to detach these features from unimportant features.

In other words we do not react to our surroundings in their entirety but only to those features which are important for us. All our experience is selective. We abstract what matters and leave the rest. Like the White Monkey we "throw away the skin". Now it is precisely these abstractions which we make from our surroundings which constitute our schemas. Thus the appropriate language for describing schemas is an abstract language. In this respect psychology is forced to follow the example of the other sciences, i.e. to abandon the crude and misleading language of daily life and invent its own special terminology. Unfortunately it has invented so many different terminologies, owing to the inevitable conflicts of viewpoint, that it is at present impossible to find any one terminology on which all psychologists are agreed. And even when we use the same terminology we do not all attach the same meanings to the terms. The word "schema" itself has been given quite a range of meanings by various authorities. This,

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however, is not entirely a matter of disagreement but partly a matter of using one central idea to explain a variety of different problems. Taken together these various applications of the idea of the schema build up an important and valuable psychological theory. To this we shall now turn.

TWO

THE SCHEMA

AT this point it will be convenient to introduce the concept of "Schema" which Head (1920) put forward to explain how changes in the posture of a part of the body are recognised. . . . The primary word-schema stands midway between the variable sounds of the uttered word and awareness of its meaning. It is, as it were, the key which unlocks the meaning of the word. Keys may be of different metals but they must have a common pattern and one which corresponds to the lock if they are to unlock the door.

SIR RUSSELL BRAIN (Neurology, Vol. IIT)

TWO

THE SCHEMA

WE have seen that the schema is a more or less enduring pattern of brain-activity resulting from an abstraction made by the individual in response to some important feature in his experience. It can become important only through repetition. Thus it is the result of a *learning* process. During this process the irrelevant and variable features are eliminated and it is the constant feature (e.g. the heat of a flame) which is preserved. To say that the schema is an abstraction is not to say that it represents something unreal. Heat is very real. The point is that in our surroundings heat is always associated with other things—flames, kettles, sunshine, etc. Thus heat considered *alone* is an abstraction. We can regard the mind as a system whose function is to make and preserve useful abstractions. But these abstractions are no less real than a rasher of bacon. The rasher is not the whole pig but it is a useful slice of it. We are compelled to slice up our surroundings because there is too much of them to take in as a whole.

Secondly the making of schemas starts at birth and goes on throughout life as a necessity for living. In other words the making of abstractions is not merely a hobby for philosophers but a necessity of practical life beginning in the cradle. The schemas are *functional* in very much the same sense as a liver and lungs are functional. They have important work to do. They are the means by which we make for ourselves an inner model of the outer world—and indeed of our own bodies. And it has to be a *working* model.

This brings us to the third point, viz. that although each schema is the result of a process of abstraction it must not be thought of as a sort of static sketch or inert formula. If it has a function to perform it must have energy and life of its own. It must be capable of somehow reaching out and influencing its neighbours which are also schemas. We can think of the schemas as forming a sort of living community. There must be laws of force and laws of communication governing the interaction of schemas, even though we cannot yet formulate them at all adequately.

Fourthly in this community there is likely to be a hierarchy of powers and functions. There is much evidence to suggest that there is one overwhelmingly important and complex schema which dominates the rest, and this is called the "Body Schema". (In the history of this theory it was the Body Schema which was first conceived by Sir Henry Head, the famous neurologist, nearly fifty years ago. He asked the apparently simple question "How does the body organise its postures and movements, since in order to move it must always start from where it is, and how does it *know* where it is?" The

answer he gave was the concept of a sort of consolidated information report from all over the body, kept continuously up to date, telling the brain exactly where every part of the body is and how it is moving at any moment. This "report" constitutes the Body Schema.)

For each of us our body is the centre of our surroundings and what happens to our bodies is far more important than anything else. Thus the sheer volume of information supplied by the body to the brain is enormous. Although it is difficult to think of an abstraction as having a *size* the fact that the Body-Schema involves a very large amount of brain-activity does justify us in saying, somewhat loosely, that it must be larger than any other schema. It can be regarded as the basis of the mental "self". All the other schemas are like planets around this central sun.

The fifth point is that since the brain is the chief ganglion of a complex and diversified nervous system, and since the schemas are defined as patterns of brain-activity, the diversity of the nervous system is likely to be somehow reflected in a diversity of schemas. This gives us at any rate one possible principle of classification for the schemas. The schemas represent the abstractions made by our senses from the streams of energy constantly impinging upon us from our surroundings. This energy consists of heat, light, sound, mechanical force and many other forms. Scattered all over our body is a variety of specialised sense-organs. These become excited by particular forms of energy—the eye by light and colour, the ear by sound, the taste-buds by chemical action, the nose similarly, the skin by touch, by pressure, by heat and by cold, and the semi-circular canals of

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the inner ear by movements. The muscles themselves contain important sense-organs called "proprio-ceptors" which respond to every action made by the body. The internal organs likewise contribute their quota of information from "intero-ceptors" in the lungs, viscera, etc.

These various senses sometimes act together, sometimes separately. We may both see and hear a person or we may only see him or only hear him. Thus the brain can distinguish different qualities of experience. We learn to recognise a whole range of colours apart from coloured objects, and this is one important series of abstractions. There is another series for sounds, and others for taste, smell, tactile qualities, rhythms, heat and so on. Thus we come to build up a very large family of schemas representing our whole range of sensory experiences. But these will not be arranged neatly and uniformly in the brain like the samples in a paint-manufacturer's catalogue. An artist, for example, will have a strong interest in colour and will have developed quite a complex arrangement of his schemas in association with his skill and imagination. An athlete will similarly have a very strong organisation of *movement schemas*.

The different qualities of experience constitute but one of the factors tending to group schemas into particular types. Our surroundings appear to us as having not only qualities of colour, sound, etc., but also as having *shape* and *pattern*. Things are round, square and pointed, etc.; they are mottled, or crinkly or rough, etc.; they are arranged in various orders, at various angles, at different levels and at different distances. In exploring all these differences we build up our idea of *space* and

this gives us a whole family of schemas which are of fundamental importance in helping us to orient ourselves to our surroundings.

Then again our surroundings are not static. We live in a world of change, of diurnal and annual periodicity, of meal-times, work-times, bed-times, of walking, dancing and skilled movement. To adjust to all these we build up a notion of *time*. This is likewise compounded of a whole family of schemas to some of which we give names, as in music or the clock or the calendar, but others are so subtle that though we work with them we cannot name them.

Quality, form and time are universal features of our experience and are thus basic in the classification of our schemas. But they are not necessarily the most obvious features of our experience. We see a room as articles of furniture, carpets, curtains, pictures, etc., and people sitting or moving about or doing things. Irrespective of its particular colour, shape, etc., we see a chair as a *chair*. We classify it, intuitively, as belonging to a certain type of furniture. We can do this only by virtue of a schema which we already possess. We classify people as male or female, old or young, wife, brother, doctor, teacher, friendly, irritating, and so on through an endless range of differentiating characteristics. These are not tied to any particular colour or pattern or rhythm but result from an extended experience of very complex differences. It is by means of such schemas as these that we build up our inner model of the everyday world.

By a refinement of this process, using instruments and laboratories, we build up another world, a world of atoms and molecules, of electric and magnetic forces, of

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chemical processes, of biological tissues and functions, of astronomical constellations and movements, the world of science. In this our schemas are far more definite and consistent, and far more systematically organised. They also take on more of a public and uniform character since they have been arrived at through the work and communication of many minds and there is much less play for individual fancy.

Beyond this elaborate and systematic world of science there is still another family of schemas, viz. those representing the abstractions of philosophy, of religion and ethics, of art, music, literature and of all such experiences by which we arrive at what are sometimes called "things of the mind", not altogether inappropriately.

This four-fold system of schemas giving us the world of perceptual experience, the world of everyday things, the world of science and the world of imagination, represents only a very crude sorting out of the enormous wealth of schemas which go to the making of any mind with any claim at all to education. Obviously anything like a comprehensive list would fill an encyclopædia, and this gives some idea of the magnitude of the task which faces psychology. And nothing has yet been said to indicate how *language* enters into the development of schemas. This is such a complex problem that it can only be glanced at here.

We all value our experience, and for a very good reason—it gives us power. Something of what has happened to us in the past is preserved for guidance in the future, it is by means of the schema that this preservation is achieved. During the early months of a baby's life his senses are busy transmitting impressions of touch, taste,

smell, sight, sound, movement, etc., to his brain, where the endless mirroring process of schema-formation is going on.

By this process he builds up his store of what we may call Primary Schemas. They are all his own. At this stage although mother and home decide *what* impressions shall impinge on him, only his own little brain can work out what to do with them. At first he does not even know that his mother is a person. She is merely a succession of warm and gratifying experiences. He cannot distinguish his own body from his surroundings until he has begun to move arms and legs, to reach out and touch himself and his cot, to crawl and to explore. There seem to be two great differentiating factors in his experience—the distinction between the pleasant and the unpleasant, which gives *values* to his experiences, and the distinction between *me* and *not me*, which gives *location* to his experiences. Thus value and location seem to be the chief agencies of schema-formation at this stage. The baby's inner world starts as "one big booming buzzing confusion". Within a few months it has sorted itself out into one body of supreme importance, his own, a second body of great value and power, his mother's, a variety of other beings who come and go, and a miscellaneous remainder of things which can either be moved or stay put and which bring various kinds of pleasure or upset. He has built his first little world and, though all sorts of variations go on in it, on the whole it is stable and dependable.

Now for the normal child this is not a silent world. His mother coos at him, the dog barks, the door bangs, the kettle whistles. He himself contributes his quota of

sounds, and he himself hears them. But these sounds differ from the rest in that he feels himself making them. He experiments, he gurgles and babbles and yells, and gets different feelings with each from his lungs, his throat, his mouth, his lips. Sound, he finds, is something he can control, like his hand. Indeed it is a kind of extra hand, for he can reach out with his voice and drag his mother over to him or push his tiresome sister away with it. Here is power indeed.

He then makes the important discovery that certain sounds made by his mother bring with them certain additional experiences. She is not merely cooing at him, she is saying "sweetie" or "bye-byes" or "potty". And having now had some months of experimenting with sounds himself he makes his first efforts at producing sounds with a meaning. And thus he enters a new world, the world of *other people's* schemas. He is now no longer dependent on his own unaided efforts to discover what is important or unimportant, what is nice or nasty, what is lasting or evanescent, what is good or dangerous—though of course these discoveries continue. Through language the endlessly rich world of adult schemas is now increasingly available for him. Knowledge which took mankind hundreds of thousands of years to build up is his within a matter of three or four years. For in language we conserve the schemas of past generations. If you listen to a child of four talking and compare his knowledge with that of an ape you suddenly realise that there is a million years between them.

Thus after the first ten or twelve months the child's little world of schemas suddenly expands quite dramatically to take in the world of his parents and ancestors. At

first this world depends on what the voices of those about him (including the radio) bring him, in quite erratic and unpredictable patches. But from about five or six another miracle opens up whole new territories by means of *books*. And then school takes a hand and starts to impose some order on his world. More and more new schemas take shape, giving an architecture to his young mind.

In this process there is a constant struggle going on between the way in which the child's primary schemas (which are non-verbal and baby-made) are struggling to shape his world and the way in which the schemas of adult culture are trying to shape it for him, the struggle, if you like, between dreams and realities, or between *me* and *them*. It is a struggle which neither side must win, for sanity depends on a balance between the two. If the *I* wins outright the child retreats into lunacy. If *they* win outright he becomes a nonentity. Fullness of life depends on the continuation of this struggle.

Man's supremacy over all other living creatures has resulted from his control of the wastage and profligacy of nature. He gave up his reliance upon the random provision of beasts and fruits and ordered their growing himself. This in turn required him to order his own life, to live in cities. To build these demanded an ordering of his own mind. It is still a grossly untidy affair but through his steady accumulation of workable schemas he has achieved great economics. These schemas are embodied in his language and are preserved and passed on through education. Without them he would relapse into barbarism.

All this can be summed up by saying that what we call

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the "mind" of the individual is a *schematic adjustive system*. It consists of economical abstractions from experience made partly by the individual and partly by the race, which work together in a more or less systematic fashion to enable the individual to make that ever-necessary series of adjustments which we call "living".

There is one further point about all this. Primitive man was able to get on without this elaborate system of cultural schemas which civilised man has constructed, though of course he had his own schemas. Schemas are economies. Mind economises action. It replaces trial-and-error action by thought-out action. But what happens to the energy thus economised? "Satan finds work for idle hands." The mind will *not* stay idle. Today it has far more energy than is needed to satisfy the practical needs of the body and it is man's tragedy that, collectively, he has so far produced such a muddle of conflicting schemas that he has come near to destroying civilisation in order to sort out the muddle. Who will find the answer to this?

THREE

THE SCIENTIFIC APPROACH TO LEARNING

UNFORTUNATELY, the fact that learning psychologists deliberately chose not to concern themselves with "real" life situations has not always been realised.

*KENNETH W. SPENCE, The Kentucky Symposium
on Learning Theory*

Perhaps we are somewhat over-ambitious and have assumed that psychology is more advanced than facts warrant.

NORMAN R. F. MAIER, Kentucky Symposium

THREE

THE SCIENTIFIC APPROACH TO LEARNING

LEARNING is almost synonymous with living. "We live and learn." All animals learn and the more complex they are the more they have to learn. They have to learn about their surroundings and about themselves in order to bring about a continuing satisfaction of their needs and an avoidance of life's dangers. But there is a very great difference between human learning and the learning of all other animals. Man recognises his need for learning and can *set himself to learn*.

There are many other differences, of course. Man has created a far more complex environment for himself than any other animal. He therefore has very much more to learn. Many animals, living in a relatively unchanging environment, are born with stereotyped reaction-patterns, i.e. *instincts*, which save them a great deal of individual learning. For the rest of their living requirements nature provides rewards, punishments, repetitions

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and associations through which each individual creature gradually builds up his own inner schematic world, and his own repertoire of skills for holding his own against the outer world. But he lacks the foresight to set himself to learn against future requirements.

Learning has become one of the most important of all psychological topics in recent years. There are many reasons for this. For a long time it was supposed that all the essential properties of a living creature, viz. breathing, feeding, moving, growing and reproducing, were essentially the concern of the biologist. Only recently has the part played by learning come to be fully appreciated and this brings in the psychologist. Psychology is not solely concerned with man but with all animal life.

The experimental psychologist is attracted to animal learning for many reasons, the chief being that he can do pretty well what he likes with animals (so long as he does not raise objections from the R.S.P.C.A.) whereas human beings are often tiresome to handle scientifically. The result is that although thousands of experiments on learning have been performed, and many elaborate theories of learning have been put forward, these are nearly all based on the simple and artificial laboratory experiences of small animals. No one is more insistent than the psychologist himself on the danger of applying his findings from animals to humans. It is a psychologist, Bugelski, who points out the fallacy in the syllogism—

“All rats are mammals,
Man is a mammal;
Therefore man is a rat”

and Bugelski goes on to say—"The suggestion that because the rat is a mammal, and a vertebrate, and has a central nervous system with a brain is not quite enough to make an equation with man" (B. R. Bugelski: *The Psychology of Learning*, Methuen).

At a time when Pavlov's celebrated work on the conditioning of dogs is being more widely appreciated than ever before, a time also when man's individuality is being threatened as never before, it is well to pause before asking how we can apply the laws of animal-learning to man. The mass-application of conditioning techniques, whether in the interests of advertising or of politics, is as great a threat to man's existence as an individual as is the H-bomb to his existence as a species. Perhaps the question to ask is not "*Can* the laws of animal learning be applied to man?" but rather "Should they be applied to him?"

The answer is not a simple "No!" because we cannot simply deny the large animal element in man's nature. Man breathes and feeds and grows and reproduces by very much the same biological processes as other mammals. But he *moves* very differently: he does vastly more with his fore-limbs; he has developed his vocal organs into a communicative instrument far exceeding the scope of any other mammal; and his brain is of unique power.

Now these distinctively human acquisitions are not merely added on to man's animal make up. We cannot say:

$$M = A + H$$

where

M = man's total make up

A = man's animal make up

H = man's human make up

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For even among the higher animals we find that their "higher" acquisitions modify their more primitive natures. An animal is not an additive mechanism but an *organism* and so is man.

Thus we can neither ignore the part played by animal learning in human learning nor assume that he retains his animal features unchanged by the fact of being human. We must take him as he is, a "higher" animal whose higher features modify and control the lower features.

The value of animal learning for psychology is that it enables us to investigate how learning takes place in relatively simple creatures under relatively simple conditions and so to gain insight into the problem. It cannot *solve* the problems of human learning but it is a valuable first step. Every science must be given time to grow and must start from simple problems before it can move on to more complex ones.

Even in the field of animal learning we are a long way from any agreed comprehensive theory about how it happens. Indeed there may well be quite a variety of radically distinct types of learning involving different processes. In Chemistry the word "matter" covers over a hundred distinct species of atoms, many of them having a range of isotopes to make things still more complicated. The number of possible interactions between different atoms is virtually unlimited. Learning is a process in which an organism is interacting with its environment. There are millions of different organisms and we simply do not know how many different kinds of interaction there may be. There may turn out to be, say, about a dozen distinct types of learning, or it may run

into hundreds or even thousands. It is safe to say that human learning will continue to present problems for the next fifty years. Thus this is no time for dogma.

One value in this type of research is that it continually stimulates the invention of new experimental techniques. But an even more important outcome is that it enables us to add to our list of *variables*. We may not be able to apply the *laws* of animal learning direct to human learning but this whole mass of experimental research on learning is giving us a growing list of *measurable quantities* which all play a part in the learning process.

If you look into a laboratory where an experiment on learning is going on you may see a monkey or a cat with some kind of box with a latch or string and somewhere a reward in the form of banana or fish. The experimenter looking at the same scene will see very much more. Much of what he sees is abstract. He sees an experimental *design* whose parts consist of measurable quantities or variables. He sees the *distance* from monkey to the banana, the *time* since the monkey was last fed; the *number of operations* which the monkey must perform to reach the banana; possibly the *size* of the banana; the *pattern* of movement involved; perhaps the *age* of the monkey; the *number of trials* already performed; the *percentage* of successes; and so on.

Thus whereas the non-scientific onlooker sees an experiment in terms of animals or people doing things with apparatus the scientist sees through this to an abstract pattern of variables. It is his job to make sense of that pattern. And the main difference between experiments with animals at different levels of the evolutionary scale is in the number and kinds of variables involved. The

more sensitive the creature, i.e. the more complex its nervous system, the wider the range of variables which affect its learning. Thus man, with the most complex of all nervous systems, is affected by a much greater range of variables than any other creature. Hence the difficulty in arriving at any quite conclusive laws concerning the learning processes of man.

It must be frankly admitted that experimental psychology has not yet succeeded in presenting education with any clear and well-founded body of guiding principles on the practical problems of learning. As Bugelski says: "There is a great gap between the laboratory and the classroom. Nothing is gained by ignoring this gap." In spite of this textbooks of educational psychology have been pouring out now for several generations. All have something to say about learning, very often with reference to experiments. How are we to regard their advice? I think the fairest view is that education is very like cookery. There is some very good cooking going on and a lot that is not very good, some being well-nigh poisonous. Some day there may be a real science of cookery based on physics, chemistry and biology but these sciences are not yet advanced enough to tell the good cook more than he has found out by rule-of-thumb, though they can often tell the bad cook what *not* to do. Good cooking is a matter of experience, skill, good recipes, sound materials and the right conditions. Much the same is true of good teaching.

Another important point of resemblance between cookery and teaching is that most really successful cooks stick to well-tried methods, and though they may experiment a little occasionally they maintain a high customary

level by relying on recipes which they know to be good. The same is true of the successful teacher. He needs to create confidence and to do this he must be secure himself. To achieve this he works within a framework of familiar devices, skills and techniques. He may not hit the educational headlines and he is the despair of the educational reformer (who has often been so badly taught himself that he wants to uproot the whole educational system) but he gets the results and the children trust him.

There is a very fundamental reason for this. Although every living creature depends upon a continuous stream of stimulation from its environment it also needs a stable framework in which nothing goes to extremes. We can tolerate only so much variation of temperature, of gravity, of noise, of fatigue, of toxins, and we need rhythms of variation to keep our systems running healthily. In any one framework the variables settle down to a working balance and the organism itself finds its optimum response. What is so disturbing is to be exposed to erratic changes of framework.

The lesson from this is that in applying the results of any scientific experiment we must ask not only whether the conclusions of the experiment were valid but also whether the framework in which we wish to apply them is the same *kind* of framework as that of the experiment. Most of the efforts of experimenters hitherto have been directed towards discovering the "laws of learning". It is likely that there are as many different laws of learning as there are frameworks in which learning goes on. Thus it would be more profitable, for a while at any rate, if the experimenters would pause in their search for laws and pay attention to the exploration of frameworks. If more

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workers would combine together to study the laws of learning in a few well-chosen frameworks, chosen for utility as well as scientific interest we might begin to get some really scientific recipes for learning.

The student of the learning-process, whether teacher or learner, is therefore well advised to look askance at books which, out of a hotchpotch of experiments on salivating dogs, monkeys grabbing bananas, cats opening puzzle-boxes, rats running mazes or telegraphists learning Morse Code, concoct general principles of learning to apply to teachers of geography, students of mathematics or pilots learning to fly. Let us each work out our own recipes in our own kitchens.

Learning as a practical task for the solitary student occupies a framework of its own, with quite unique problems. The student has to learn a lot about himself and also to get rid of a lot of fallacies about the nature of books and authors. To this topic we now turn. All that was said in Chapter Two about "schemas" is relevant here, though it will be discussed in more homely language. What the solitary student has to do is to build up his own system of schemas from material supplied by the textbook.

FOUR

THE INDIVIDUAL APPROACH TO LEARNING

*TO bend our souls to the having or doing of
that which they see to be good.*

HOOKE, Laws of Ecclesiastical Polity

*Example of a student who
debauched his study habits*

FOUR

THE INDIVIDUAL APPROACH TO LEARNING

MANY students inflict unnecessary handicaps on themselves in their efforts to learn. Learning has come to be so closely associated with school time-tables that it seems almost impossible to learn anything unless it is measured out in equal daily doses. I am sure that many home students torment themselves and exasperate their families by their anxieties and panics through their obsessional attempts to work to a rigid schedule. Such students can be more shocked by the suggestion that a little irregularity in their study-habits might actually be good for them than by a suggestion that an occasional drunken debauch might not be a bad thing.

This "Eric, or Little by Little" notion of learning must now be exploded. It is based on three fallacies: First, the fallacy that knowledge can be parcelled out into equal doses and still preserve its essential character; second, the fallacy that the mind can grow by steady equal increments; third, that it is possible to live a life of

regular clock-like learning habits and still remain human in the modern world. Let us think about this last point first.

Have you ever stopped to think how unnatural it is to live by the clock? Or to wonder how it came about that our civilisation came to be so preoccupied with time-keeping? It is true that time and rhythm run through all animal life. There are the external rhythms of the sun, the moon and the tides, and the internal rhythms of heart-beat, appetite, menstrual periods in women, and other subtle ebbs and flows which we are only just beginning to understand. When I say it is unnatural to live by the clock I do not mean that we can ignore time and rhythm. Rather the contrary, what I mean is that we cannot defeat all these varied natural rhythms by imposing on ourselves a uniform mechanical rhythm.

The American philosopher and sociologist, Lewis Mumford, has given a fascinating account in his "Technics and Civilisation" of the process by which mechanical time-keeping crept into our social life and came to dominate it. Oddly enough it was the compulsion of the spiritual life which fastened on us the fetters of mechanism. With such widespread chaos all over Europe in the Dark Ages following the collapse of Roman civilisation the founders of the great monastic orders sought to establish enclaves of quiet, orderly, other-worldly existence and to defeat the menace of disorderly barbarism by regularity of prayer and devotion. It was in the monasteries that the first mechanical clocks came into permanent use and to this day we look to the church tower to see the time of day. Thus time-keeping became invested with a certain moral sanction.

Later with the changing habits of life imposed by the Industrial Revolution the tempo of machines began to dominate industrial work. The moral flavour of regularity was found by shrewd industrialists to have a considerable practical value. Punctuality and steadiness at work were the chief virtues in a worker. These same virtues were also a great convenience in education. The schools obligingly supplied industry with a steady stream of workers so conditioned to living by the clock, that their consciences were as effective as the whips of the slave-drivers in the old days.

Thus to this day you and I feel profoundly guilty if we fail to keep an appointment. A journey on a fog-delayed train can give us hours of misery not because we are hungry but because we are going to be late for some meeting, which as often as not could well get on without us.

It is important to understand this slave-driver within us for he jiggers up all really *natural* approaches to the problem of learning. "Conscience doth make cowards of us all" and if we are afraid to experiment with our habits of learning we are not going to get far in improving them. But if we can dare to look the clock in the face and then turn it round to face the wall we can begin to think realistically about the essentials of learning.

To begin with we must note that there can be no uniformity about the learning process because the things we want to learn differ so widely. You want to learn to type? Or to speak Italian? Or to solve mathematical equations? Or to write essays on Constitutional History? Or to analyse chemicals? Or to interpret modern philosophers? The range is endless. How could we

possibly find any uniform method of learning to apply to such diversity of material? Obviously we must adapt our learning-habits to the material to be learnt.

There is one broad distinction to be drawn between acquisitions like typing or playing the piano, and acquisitions like speaking a foreign language, or competently discussing philosophy. The difference is that even if you have not yet learnt to type or play a piano you can watch experts doing these things and understand what they are doing. In other words the nature of the acquisition is clear to you before you start. But you cannot understand an expert speaking a foreign language or discussing philosophy. You cannot know in advance what these acquisitions will involve on the way. You know vaguely that you want to understand philosophy but you cannot plan in advance the steps needed to reach that understanding because you would need the understanding in order to determine the steps. (This is partly true of piano-playing but you do know that extensive drill is required—there is no drill for philosophy.)

Now you may say here that even if you are working on your own with no teacher to guide your steps, surely the textbook will be so arranged that you can move from step to step without needing to understand the whole thing first? It is a simple faith in this possibility which inspires writers and readers alike. Occasionally it is justified. But if textbooks could really always be counted upon to do the job there would never be any need for teachers. What then does a teacher do over and above what the textbook does? He does a number of things and it is vital for the solo student to grasp what they are because he has to *teach himself*.

- (1) The teacher has to establish confidence. "This is something which *you* can understand" is a proposition to be firmly planted in the pupil's mind. The solo student must do this for himself. "What one fool can do another can do."
- (2) The teacher has to appreciate the pupil's difficulties and adapt his treatment of the subject-matter to overcome them. The solo student must learn to identify his own difficulties. This is one of our main themes in Chapter Seven.
- (3) The teacher has to answer the pupil's questions. The solo student has to learn to ask useful questions to which he himself can find the answer by searching.
- (4) The teacher has to devise a strategy which will sustain morale and win the battle of understanding. The solo student has to fight this battle unaided, except by the textbook, and must therefore give a good deal of thought to his strategy. The enemies he is fighting are within. They are ignorance, misconceptions, boredom, laziness and cowardice.

Let us deal with strategy first. Doubtless you could adopt the simple strategy of saying: Here is a textbook of ten chapters which must be learnt. I will read and re-read one whole chapter every week until I know it practically by heart. In ten weeks I shall know the whole book. If it is fairly easy material and if you can organise your life so as to stick to your schedule this method can work. Many students follow this method in working for examinations and if the examination demands nothing but reproductions of textbook answers the strategy pays off. But it is essentially an unintelligent method and

sometimes the examiners are not quite so stupid as the student. They want to know not whether the candidate can give the right answer but whether he has digested it. They mark for understanding not for memory. The strategy then lets you down with a crash.

But why? If we can learn by equal doses why can't we understand by equal doses? This is a little like saying—we can fly over hilly territory at a uniform speed so why can't we walk over it at a uniform speed? And the answer is then obvious enough. Knowledge is intrinsically uneven. Every new piece of knowledge, whether in grammar or history, in mathematics or in anatomy, in archaeology or in accountancy, involves new ideas—and ideas are endlessly varied. One moment you are climbing laboriously towards a peak of understanding. Having reached it you are in view of a whole stretch of easy territory which can be covered in a fraction of the time taken to reach the peak. Later comes another peak and so it goes on.

Now you might say—surely it is the business of the textbook writer who supposedly knows the territory, so to plan his chapters that the peaks of difficulty are equally spaced out? This is very nice in theory but the fact is that many of the “peaks” are subjective. They are created by varying slopes of difficulty in your own mind. Difficulty is a very relative thing. No writer can anticipate all the difficulties experienced by his reader, though he will doubtless know from experience where some of the commoner obstacles to understanding lie. And the reader himself cannot know in advance what difficulties he will meet because until he is in the thick of them he cannot imagine them.

This is why strategy is so essential. Strategy involves reconnaissance. You don't wage a campaign at a fixed rate of x units per day. You send out scouts or aircraft to see what lies ahead. You gain a general idea of the nature of the terrain and of the disposition and movement of the enemy's forces. You take account of your own manpower and armaments and of what you can hope to do with them. And you try to engage the enemy on the terms most favourable to yourself.

You are campaigning for knowledge. It is best not to think of the campaign in terms of mastering a single textbook. You need other works of reference, dictionaries, atlases perhaps, historical or mathematical tables and the like. You also need access to a library where further works, particularly encyclopædias, may be consulted. For any particular piece of study you may not need all these things but you are likely to need some. Thus your first task is to find out what your requirements are likely to be. This leads us to consider how best to attack a new book.

At first it seems natural enough to say that to master a book you must start at the beginning and go through to the end, for the author wrote it in that order and he knows best. This is true for detective stories which you read for the thrill of suspense and surprise. But in study-books you are seeking not entertainment, but understanding. I shall have more to say about understanding in the chapter on "Knowing" but I have already suggested that in the workshop of the mind understanding is a process of drawing mental sketches. If you look at a picture of an internal combustion engine it is not enough merely to see it as a picture. This is what

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we call "perception" in psychology. You need to see through the picture to the skeleton of the thing so to speak. In other words you need to see it *abstractly* as a set of cylinders, pistons, valves and so on, each with its own function. The understanding is not given in the picture. You yourself have to create it by a process of active abstraction.

Many students waste countless boring hours poring over tedious textbooks, somehow expecting that understanding should come automatically. It is not the book which has to do the understanding, it is *you*. The book supplies materials and clues. The reader has to use these to build up his own understanding.

Now the clues to understanding cannot all be given on the first page. Nor can they be evenly spaced throughout the book. An experienced writer may do his best to distribute the clues helpfully, but he simply cannot know, for every individual reader, what the most helpful arrangement is likely to be. The book has to be written in a certain order, partly because the subject-matter imposes its own order and partly because books have to be divided into chapters and pages. The first task of the solo student is to free himself from the limitations of the textbook order. He must carry out a reconnaissance and draw a rough map. Take a large sheet of paper and divide it up into as many squares as there are chapters in the book. In each square write the chapter heading. Then skim through the book to get an idea of the really important *words* in each chapter. You can normally find clues to the importance of words, e.g. paragraph headings, use of italics or heavy type, titles of diagrams, summary at end of chapter. You may find a dozen or more key

words in each chapter. Write them down in the square for that chapter.

You may not know what any of these words mean at first. They are unknown objects in enemy territory. But at least you know that they are *there*. They are positions to be attacked and held. And usually they will not *all* be completely unfamiliar. In fact you will do well to sprinkle a certain number of familiar words in each square along with the unfamiliar ones. Birds of a feather flock together and you will get some sense of the meaning of the unfamiliar words from recognising their companions. The business of exact understanding has not started yet. This is merely "softening-up". But it is a very helpful *preliminary* to understanding.

One of the chief aims of this book is to help you to *understand your own understanding*. Let us examine this "softening-up operation" and see how it works. Consider what happens when you meet a stranger for the first time—someone with whom you have to do business. I do not mean a single business transaction but something involving a good deal of give-and-take, e.g. you are going to start a tennis club together. It is important for you to get to know how his mind works and what are his prejudices and awkward points. Your opening conversation is exploratory. You don't, of course, give him the "third degree" as a secret police agent might with a suspect, but you definitely want to find out all you can about the chap.

Now as you know, "There's nowt so queer as folks." If, therefore, you have found a technique for exploring the views and attitudes of such a complicated being as another person you should not find it too hard to explore

the ideas and intentions of a textbook. But why is this exploration so necessary? The answer can be found by asking another question: What is a *difficulty*?

A difficulty is a resistance experienced by a reader when understanding fails him for obscure reasons. The obscurity is an essential factor because if you immediately see why you cannot understand something you either remove the obstacle or recognise it as unsurmountable. I do not find a Chinese text difficult—I find it impossible. But I find many English texts difficult just because knowing the language make me feel I *ought* to understand and I can't at first see why I don't. I am therefore vaguely aware that an effort is called for. We say a thing is difficult if it requires us to make an effort.

It follows that if you want to become a successful reader, i.e. one who can take on and subdue any subject he wishes to master, the most necessary equipment is the art of identifying difficulties. This art serves the reader in the same way as scientific criminology serves the detective. It provides him with techniques for tracking down culprits. Such a vitally important art requires a whole chapter to itself (Chapter Seven).

FIVE

REMEMBERING

I HAVE written a book preoccupied, in the main, with problems of remembering and its individual and social determination. But I have never regarded memory as a faculty, as a reaction narrowed and ringed round, containing all its peculiarities and all their explanations within itself. I have regarded it rather as one achievement in the line of the ceaseless struggle to master and enjoy a world full of variety and rapid change. Memory, and all the life of images and words which goes with it, is one with the age-old acquisition of the distance senses, and with that development of constructive imagination and constructive thought wherein at length we find the most complete release from the narrowness of presented time and place.

SIR FREDERICK C. BARTLETT, *Remembering*

FIVE

REMEMBERING

WE can begin by admitting two things. First, that psychologists are still a long way from understanding fully how memory works. Second, that people differ widely both as regards *what* they remember and as regards *how much* they remember. It is, however, true to say that individuals can improve their techniques of remembering and that the more psychology can tell them the more they can hope to improve. Indeed this is one of the things which teachers ought to be learning from psychology and passing on to their pupils.

Education is forever swayed by swings of the pendulum. When in this country, universal education became compulsory, there followed a great proliferation of examinations. These put memory at a premium. Then came the inevitable reaction. In the 20's we had *The New Psychology* and *The New Education*. Memory and discipline went by the board in favour of freedom and self-realisation, at any rate in the more aggressively

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modern books on educational theory. At the same time intelligence tests were designed to eliminate, as far as possible, any advantages accruing from "mere memory".

It is not without significance that one of the most popular topics of current psychological research is memory. It is to be hoped that education will be no less prompt in reinstating this long-despised faculty than it was, a generation ago, in rejecting it. For in truth it is the necessary foundation for both knowledge and wisdom. In this argumentative world it is not enough to be "full of wise saws"—you need the "modern instances" to substantiate their wisdom. The prompt application of professional competence, whether in the law or in medicine, teaching, social welfare, engineering, administration or any other field, rests on a well-equipped and disciplined memory.

Where psychology can help is by showing, to teacher and learner alike, that efficient memorisation is not synonymous with blind repetition. Even an actor learning his part, which he must render word-perfect, must do a great deal more than repeat. He must *interpret*. He must make the meaning of the part, both in itself and in relation to the character and the context, entirely real to himself so that he speaks his lines with the freshness of a first utterance,

Consider a very different example—the multiplication table. Here blind repetition gives, apparently, complete mastery. But whereas the actor must interpret his lines *in their context* the learner of tables must learn to use them *out of context*. It is not very useful to learn that six sevens are forty-two if you can only recall it by first saying "five sevens are thirty-five". In this kind of

learning the learner has to learn to detach the material learnt from its context. In both cases successful memorisation depends on *intelligent interpretation*.

Now this requirement might seem at first sight to make the task of memory harder. For repeating plus interpreting would seem to be a heavier task than repeating alone. Here experimental psychology steps in and shows that, paradoxical as it may seem, the effort of interpretation *lessens* the burden of repetition. You can prove this quite directly by taking as a task for memory the learning of something which calls for no interpretation such as a disconnected sequence of words, e.g. "bridge say any if ought darker care in" and find how many repetitions are required to learn it. Then try "I then no thirst nor hunger did perceive" (Traherne *The Preparative*). Psychology has long known that meaningful material is much more rapidly learnt than meaningless material. But this implies interpretation. Thus the extra mental work of interpretation facilitates the work of memory. We are so familiar with this basic fact about memory that we are inclined to take it as self-evident. So much so that given a task of learning a set of disconnected items we are fond of putting them into a verse or some other pattern which imposes an extraneous form, e.g. "Thirty days hath September . . ." The verse-form is certainly a help but it is by no means essential. The mnemonic for the order of the planets: "Men very easily make jugs serve useful and numerous purposes"* is not a verse but it fixes the initial letters of the planets in a sentence, whose very silliness helps to make it

* Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

in-ert · powerless to move itself,
1 - sluggish

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remembered. The fact that the interpretation of the sentence has nothing to do with the items to be remembered does not seem to detract from its efficacy.

We could explain this fact crudely by saying that the mind is always *wanting* to interpret. Given any meaningless and disconnected set of items it either feels thwarted and rejects them or it sets to work to *impose* an interpretation. This has been explained in different terms by different psychologists. Thus Spearman postulated a law to the effect that the mind is always tending to find *relations* between the things in its experience. This is certainly part of the process of interpretation, but Spearman did not give us many clues as to why certain relations rather than others will be evoked. Freud had plenty to say about this and looked usually for an unconscious motive controlling conscious processes in such a direction as to reduce tension. The Gestalt psychologists regarded the force as one which always works in such a way as to arrange experience in the smoothest and neatest patterns—just as the surface tension in a wobbling soap-bubble works to pull the bubble into a spherical shape.

These are only partial explanations and obviously the stored experience of the individual has a lot to do with the particular interpretations which he will impose on his experience. The important point is that the mind is not regarded as a wax tablet on which experience is passively recorded, but as an active system of forces. Moreover these forces are at work not only when we are having new experiences but afterwards as well. Our memory is not an inert store. One of the most important and systematic investigations of memory in the modern period of psychology was made by Sir Frederick Bartlett

(*Remembering*, 1932, Cambridge University Press). The experiments are too numerous even to summarise here but the firm conclusion reached was this:

"Remembering is not the re-excitation of innumerable fixed, lifeless and fragmentary traces. It is an imaginative reconstruction, or construction, built out of the relation of our attitude towards a whole active mass of organised past reactions or experience, and to a little outstanding detail which commonly appears in image or in language form. It is thus hardly ever really exact, even in the most rudimentary cases of rote recapitulation, and it is not at all important that it should be so."

This last remark refers to the inexactness of our memory for ordinary daily events. Obviously there are cases (e.g. in preparing for examinations, or for acting in a play) where exactness is necessary. We then have to work hard to achieve it. This work will be more effective if we understand the forces in our own minds which make exact memory so difficult to achieve.

The various systems for "improving the memory", advertised from time to time, do not find much favour among scientific psychologists. This is not just "snootiness". One reason is that there is no such thing as "the memory". We all have ways of storing our experiences but these ways differ widely from one experience to another and from person to person. Some remember best through seeing, some through hearing, some through feeling and some through action. Moreover the kinds of thing which it is important to remember vary enormously according to one's job and one's situation in life. Thus it is very doubtful if any principles of memorisation could possibly apply to all cases.

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In the Introduction we deliberately restricted ourselves to the problems of the solitary reader, the reader who wishes to read, to understand, to retain and to recall, so that in the end he can truly be said to *know*. From all that has been said it should be clear that mere passive reading will not produce the desired result. The reading must be *interpretative* and this means not merely understanding the surface meaning of the words but following out their implications. The interpretations must be given both depth and strength.

Even in the most scatty-minded individual the mental schemas tend to form a system or *hierarchy*. The more powerful members of the hierarchy are few in number and exert a kind of control over the less powerful. In this system the newcomers do well to find some access to the "high-ups" so as to secure their position. Thus it does not matter much whether your whole system revolves round Football Pools or Shakespeare or Politics, so long as you find some way of relating whatever new things you wish to remember to the central schemas in your dominant interest.

Most people would agree that serious reading demands concentration but they are apt to suppose that this means shutting out everything else from one's consciousness and forcing oneself to attend strictly to the subject matter of the book. This is often so difficult that some students become almost suicidal because their minds will not submit to this self-bullying. The normal condition of the mind is one of incessant activity. Shutting this off requires such an effort of inhibition that little energy is left for the business of reading and interpreting. Why not try *using* this activity instead of trying to strangle it?

In other words whatever you are thinking about let it go on simmering as long as it wants to, while at the same time starting to read. Let the two processes fuse instead of clashing. Let your study of Roman History fuse with Football Pools, what games did the Romans play and how did they gamble? Did they have bets on the gladiators? Or let your study of Stocks and Shares fuse with Shakespeare—what about the economics of the Merchant of Venice? Or let your study of Biology fuse with your enthusiasm for Politics. In swotting the dissection of the frog think of the anatomy of the State and draw parallels between the Body Politic and organs and tissues depicted in the text.

You can always find analogies. We are forever being warned that analogies are dangerous. So is string if you tie it round your neck. It is dangerous to use analogy for argument unless you make certain that the two halves of the analogy are exactly matched in the particulars which matter for the argument. But what we are concerned with here is not argument but memory. The analogy is merely a link, a line of power-transmission to enable the energy of your major interest to flow into the dead text in front of you and bring it to life. The logical validity of the analogy is irrelevant. It serves as a letter of introduction for the timid newcomer to give him access to the influential tycoon.

In this way the schema of the reading matter gains depth. It takes root in the soil of your major interest. But it will still need husbandry to enable its roots to become stronger. The oldest law of learning is still true—*Repetitio mater est studiorum*. It is through repetition that the bonds of memory are strengthened. But not

mechanical repetition. It is not *mouth*ing but *mind*ing which counts. Not monotonous repetition with the text in front of you but the recall while shaving or on the bus or best of all with some fellow-reader. The fact that you are a solitary reader does not require you to pursue your understanding in solitude. So long as you do not bore your friends it can make a very significant difference, both to understanding and to memory, to talk about your reading to other people. They need not even be fellow-readers so long as they are willing to listen. They need not be well-educated—in fact often the educationally under-privileged have quite a thirst for knowledge. Many a railway journey can be spent with mutual profit by simply talking to your fellow-traveller about what you have just read. And his questions may force you to think again about what you thought you understood. The great point is that you are keeping the schema alive and strengthening its roots.

Part of the secret of this process lies in the fact of *translation*. You are expressing your understanding of the text in your own words. Often you may find that you can express it in a diagram. Or if the text contains diagrams you can translate these into words. Either way you are strengthening the essential schema by stripping it of non-essentials. For every schema is an abstraction and the more clearly you see the abstraction the less dependent are you on the exact words of the text.

The paradox of reading is that the book does most of its work after it is shut. Its work is to add to your stock of schemas. The actual reading only sows seeds. The mind itself has the essential horticultural job of tending these seeds until they burst into flower.

Whole treatises have been written on memory. It is of central importance because it enters into every aspect of our mental life. Without it we should be reflex automata reacting without hindsight or foresight to the momentary stimulation of our environment. In a very real sense we should be both blind and deaf. For *seeing* is not merely experiencing visual sensations but interpreting them and this is only possible through memory. Hysterical blindness can produce a curious state in which the eyes work normally but the brain merely receives the visual impressions without attaching any meaning to them.

The disturbed mind has much that it wants to forget, and few of us are free from all disturbance. So we have areas of forgetfulness. And given the incessant activity of the schemas, continually interacting and joining forces, an inhibition which shuts out one schema may shut out a whole family of schemas—just as one delinquent member of a human family may bring obloquy and ostracism on the rest of the family. Within limits you can use this fact to explore the disturbances in your own mind. Make note of the things which you most persistently forget and try to discover their family relationships. You will not get very far because your own resistances will thwart you and it is a job for a psychoanalyst, but you may get revealing clues. If you are prepared to be painfully honest you may make surprising discoveries about yourself.

A great deal of psychological experimentation on problems of memory has been carried out over the past sixty years—too vast even to list here. We know enough to realise that remembering, though endlessly varied and complex, is fundamentally a law-abiding process. The

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memory-prodigies who turn their gifts to profit on Television have discovered a few of the laws for themselves and invested a good deal of mental capital in them. But they pay a price for this. And unless you wish to earn your living in that particular and rather peculiar form of public entertainment it is better to aim at a more normal memory. For the mind has other work to do besides amassing quantities of miscellaneous facts.

Nevertheless in any one subject it is a great satisfaction to have most of the important facts at your finger-tips. You can set about this by exploiting the mind's *organising* tendency and by making use of the objective links which exist between the facts in any one field, whether it is engineering, or law, or chemistry, or archaeology or whatnot. Textbooks often try to do this for you by assembling groups of related facts into neat tables, e.g. the Periodic Table of Chemical Elements. The important point to grasp about these tables is that they are starting points only. They can give you what psychology calls a "set" in a certain direction. You can set yourself to systematise.

A system of knowledge is not a mere array of facts. It is a structure. It indicates a large number of pathways between the facts. And these pathways can be more important and more interesting than the facts themselves. Moreover they appeal to the relating, organising, pattern-forming tendency of the mind. Faced with such a table you should set yourself to trace out as many pathways as possible. Ask what each pathway means and give it a name. Re-draw the table leaving out the factual elements and showing it as an abstract scheme of relations. Then try to fill in the facts without the book.

All this mental activity serves to give meaning to the facts and to root them firmly in the schematic system of the mind. Further, because the facts are now inter-related, the system enables you to reason your way from one fact to another and to use your factual knowledge as a basis for argument.

One word of caution is needed here. Once this "systematising-set" grips you it can become very intoxicating. You can find yourself embarking on more and more ambitious systems. It is prudent, therefore, to exercise restraint and economy. Work with well-established groups of facts and assure yourself that the pathways you discover are secure and important. Make use of the system and try it out on other people. Otherwise you may find yourself in a maniac ward of a mental hospital with a lot of other screwy types all busy unscrewing the inscrutable in vast cosmic plans for the integration of the Universe.

SIX

KNOWING

MY perceptual "world", therefore, is a kind of map. It is not identical with the physical "world" any more than a map is identical with the country which it represents, but it is able to symbolise it because events in my perceptual "world" stand for events in the physical "world".

SIR RUSSELL BRAIN, *Mind Perception and Science*

Absolve: To set free from an obligation
or the consequences of guilt

SIX

KNOWING

IN the Introduction I defined "knowing" for our present purpose as follows:

To "know" the subject matter of a book is to be in a state of mind in which, given time, you can answer any reasonable question about the contents of the book.

This definition absolves us from dealing with all the other uses of the verb "to know" which have perplexed generations of philosophers and psychologists. But it raises problems of its own. What is a "state of mind"? What is a "reasonable question"? and in what forms may an "answer" be required?

When a dog has been "conditioned" by Pavlov's technique so that on hearing a bell it starts to salivate we *could* call the conditioning a "changed state of mind". The bell would be a "reasonable question". The saliva would be a "correct answer". But only a very old-fashioned Behaviourist would seriously talk like this, and even he would quibble at the use of the word "mind".

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But we already have a workable definition of "mind". It is a system of schemas. Now I am not concerned here with the legitimacy of describing the dog's inner response to a bell as a "schema". It is enough that human beings have schemas and also that human beings are capable of being conditioned. The mind is an economical system and tends to make use of its past achievements whenever possible rather than embarking on fresh conquests. But life is full of surprises and the mind frequently has to work in new ways. Thus it will make use of its past conditioning whenever possible but it is frequently called upon to recondition itself to cope with new situations.

Conditioning is not a process which takes place only in a laboratory under precisely controlled conditions. It is a property of living tissue in action. When one stimulus is followed by a second stimulus after a short interval of time, and the creature responds in some determined way to the second stimulus (e.g. when offered meat its mouth waters), and if this sequence is followed many times then it is possible to omit the second stimulus and the creature will respond to the first alone. On hearing the bell its mouth waters. And we ourselves behave similarly.

The bell by itself is irrelevant to food but the conditioning process makes it relevant. And since in daily life we are being perpetually bombarded by stimuli which are irrelevant to our needs of the moment, and by few stimuli which are relevant, it will happen by chance alone, if not by contrivance, that one or more irrelevant stimuli will be followed by a relevant stimulus often enough to establish a conditioned response. When I add that from birth onwards we are surrounded by parents

and other determined conditioners you will see that no human being can escape large doses of conditioning.

Conditioning is not knowledge but it is an inescapable foundation on which knowledge must be built. Our conditioning equips us with a large number of automatisms. Most of the responses we make to the situations of our daily environment require no thought. We may be aware of our responses but they require no effort.

Our schemas have both permanence and fluidity. The permanence is due to the conditioning process by which the schema is established. The fluidity is due to forces forever at work among the schemas, as it were stretching, compressing, distorting, splitting and joining them. Part of this process we call "thought", part we call "imagination" and part "dreaming". And since the mind is forever trying to stabilise itself it tends to use the more permanent schemas as a base for operating on its more fluid schemas. Each individual tends to adopt certain characteristic modes of mental operation in accordance with his particular equipment of permanent schemas. He follows typical "strategies".

Knowledge is the means by which the mind gets a hold on what is outside itself. And conditioning is thus a forerunner of knowledge. The dog is born to salivate when it smells food. That is not knowledge but pure unconditioned reflex. It is not born to salivate at the sound of a bell. But if it finds that the world is so constituted that a bell is always followed by food then it gains a little time by learning to salivate at the sound of the bell. And in this chancy world time is very important to every living creature. As Anatole France's dog remarked: "To eat is good, but to have eaten is better,

for the world is full of enemies." You can swallow more quickly if your mouth is already watering.

Thus conditioning relates the creature more effectively to the prevailing state of affairs in his environment. Knowledge carries this relation a lot further. For a creature with knowledge has an elaborate system of schemas all representing bits of his environment and capable of many recombinations. He can internally manipulate these bits, experimenting with possible environmental changes before they happen. Knowledge brings foresight.

When we come to language and books we find the range of schemas and our powers of manipulating them vastly extended. The sky's the limit. And this brings its own disadvantages. There may be more things in heaven and earth than are dreamt of in your philosophy but we likewise dream of a great many things that never happen on land or sea. Thus the mind can easily get lost in its dreams. To correct this dangerous tendency it has forged the concept of *truth*.

Knowledge is a state of mind and truth is a relation between the state of mind and the fact. A large part of philosophic effort has gone into determining just what this relation is. For our present very pragmatic purpose we may say that where the "fact" takes the form of a book a student may be said to have "true knowledge" of the book when he can answer any reasonable examination question on it.

And this brings us to the question of what is a "reasonable question". We are not going to accept verbatim answers. It is not enough to learn a book by heart. Even if this were possible it would be silly. Every

book has what may be called a *manifest* content and a *latent* content. The manifest content is not the sum-total of words in the book but the sum-total of explicit propositions. The latent content is the sum-total of schemas which are implicit in those propositions. By this I mean that in order to make or to understand a proposition a certain framework of ideas is essential. If a bio-chemist says "Oxygen is necessary for breathing" a whole group of notions are involved in this, such as the notion of a chemical element, of a gas, of a respiratory process, of lungs, of a living organism, of metabolism, of oxidation and so on. Out of this complex of schemas comes the proposition. Having read the book the student will not get very far in answering a question on breathing if he can only say "Oxygen is necessary for breathing". It is the implications, the latent schemas, which determine the understanding of the proposition.

The reader who deliberately sets out to derive the fullest possible knowledge from a book can be helped by the realisation that this requires a search for latent schemas. Not all propositions are equally important of course but it is as well to think of the book as a body of manifest propositions surrounded by an invisible aura of implications. As he penetrates the text he can continually ask questions which coax *from his own mind* the schemas necessary for understanding. For whatever understanding he achieves is of necessity constructed from his own resources. The book does not put knowledge into his mind. It serves as a stimulus to stir up schemas already there, schemas which are then modified and grouped into new patterns, i.e. new schemas.

The "mental chemistry" of these schemas follows

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quite different laws from the chemistry of material molecules. A molecule is a piece of matter and cannot be in two places at once. But one and the same schema may be found operating on its own or as part of any number of more complex schemas. How this comes about is not our present concern but the fact that it does happen is highly important. For it introduces enormous economies into the business of the brain. It is the basis of all analogies, for example. It is also the basis of what is known as "transfer of training".

"Transfer" was a term introduced by John Locke but the notion that the mind can improve in one activity by practice in another activity was already in currency in the time of Plato. He assumed its validity without question as can be seen from his own words:

"Men of slow intellect, if they are trained and exercised in arithmetic, if they get nothing else from it, at least all improve and become sharper than they were before. . . . There is all the difference in the world between one who has studied geometry and one who has not."

Plato bequeathed the doctrine to education where it reigned almost unchallenged, except for some queries from John Locke, till the end of the nineteenth century. It gave a perfect theoretical justification for anything that school-masters wanted to teach, especially for Latin and Greek, and is still put forward today with the utmost assurance by those who prefer dogma to experiment. The rise of experimental psychology, however, put the doctrine to the test and it emerged not, perhaps, completely discredited, but considerably weakened in credibility. Many hundreds of experiments have tended

to show that the amount of transfer possible varies decisively with the conditions of training. It can be quite substantial but it may also amount to little or nothing. It can even be negative—for example a training on the piano might actually interfere with progress on the harpsichord.

But the principal gain from these experiments has been the appreciation of the complexity of the learning process. Whether we are learning to play an instrument or to speak a language or to carry out calculations or to drive a car the brain has to assemble a whole battery of schemas and to integrate them into a unified process, nicely timed and co-ordinated to the task in hand. For example the schema in which the knowledge of the keyboard and of the musical scale is embodied will play its part in all instruments with a similar keyboard but it will be related to different patterns of finger pressure and foot-movements for different instruments. The way the player sits is likely to vary slightly also. If you consider any two related activities you can to some extent analyse for yourself what are likely to be their common features and what must be different. But just how much mutual reinforcement or conflict may happen between the two activities can be determined only by experiment. What we do know is that the more you are *aware of the common features the more likely you are to transfer some of the training from one to the other.*

It is this last point which underlies the present insistence on the importance of the schema in the search for knowledge. For when reading new material you are faced with the need to construct, out of your existing stock of schemas, an array of novel schemas. It is

important, therefore, to cultivate explicitly the habit of looking out for familiar schemas in what you are reading. There is no need to construct all over again a schema which is already in your possession.

Physics is full of instances of this carry-over of schemas from one field to another. An effort is required, however, to identify the schemas for they may appear cloaked in very different language or symbolism. An excellent study of this fruitful field is to be seen in Dr. Harry F. Olson's *Dynamical Analogies* (London: Chapman & Hall Ltd.) in which it is shown that numerous identical mathematical relationships are to be found running through the formulae of four distinct branches of physical phenomena, viz. Electrical, Mechanical-Rectilineal, Mechanical-Rotational and Acoustical. The measures are all different in kind and quantity but in each case the same schema of functional relationship holds good. Thus the time spent on learning the mathematics of these four branches separately can be divided by four if they are brought together. This exactly illustrates the essential principle of transfer of training.

An odd consequence follows from this principle. In one of the Sherlock Holmes stories the egregious Dr. Watson tried to interest Holmes in the Solar System. Holmes (I forget his exact words) replied to the effect that the mind was like a furniture store and if it got filled up it would hold no more. Therefore he did not wish to clutter up the limited accommodation of his mind with items of knowledge which were of no use to him. Now Holmes, though a great detective, was no psychologist. In particular he did not understand that the logic of schemas is quite different from the logic of furniture. If

we make economical use of our schemas then the more knowledge we have the more our capacity for knowledge grows. For every new piece of knowledge brings into existence new schemas and these serve as the basis for still more pieces of knowledge. Understanding grows by what feeds on it. And the more often each schema is used in a new way the stronger it becomes and hence the firmer is the knowledge which it has already given. Thus the old knowledge speeds our grasp of the new and the new strengthens our grasp of the old.

SEVEN

THE SEVEN DEADLY DIFFICULTIES

"THOU hast read very despicable performances," said the man of letters; "but in all times, and all countries and in all kinds of literature, the bad swarm and the good are rare."

VOLTAIRE: Babouc's Vision

SEVEN

THE SEVEN DEADLY DIFFICULTIES

Unclearness, unfamiliarity, incompleteness, ambiguity, heaviness, complexity, abstractness—these are the seven deadly difficulties. There are crowds of minor ones but if you can overcome these major monsters the rest is merely a matter of mopping-up operations.

Before starting a campaign you need to make sure that you have the wherewithal for battle. As any commander will tell you the most important single factor is *morale*. Here I will introduce you to a psychological dodge which I have personally found extremely effective in building morale. I used to approach difficult books with feelings of inferiority. How could I, in all my ignorance and stupidity, hope to enter into the thoughts of such infinitely wise and learned people as writers of books must assuredly be? With such an attitude you are defeated before you begin. Many are the books I have laid aside as quite beyond me because the first chapter

Pompous Verbiage - Dictation according to word with little meaning

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convinced me that I was too stupid to go any further. My salvation came through meeting authors and discovering that they were at least as stupid as myself. This wonderful revelation saved my morale. And I then realised that the secret of successful reading is to become an Angry Young Man.

The author is your enemy. His armaments are his stupidity and laziness. With these he plants land-mines and booby-traps, he bombards you with irrelevancies and obscurities, he chokes you with the poison gas of pompous verbiage, he digs himself into an impenetrable Maginot Line of abstractions and generally does his best to prevent you from invading the territory which he regards as his own.

"But, but," you stammer, "why does he write at all, if he doesn't want me to understand?" You poor, soft boob! It was Dr. Samuel Johnson, I think, who said: "Nobody but a fool would write if he didn't have to." The miserable hack has to live, hasn't he? So he bamboozles you into buying his books. But this doesn't mean that he loves you and is going to make things as easy as possible for you. "I had to sweat to write it so let the silly clots sweat to read it!" he mutters savagely as he pens out his muddy obscurities.

So instead of being angry with yourself for failing to understand start getting angry with the author for obstructing you. You then go into battle fighting mad. Mutter fierce imprecations as you trip over his barbed wire, hurl hate at him as he knocks you off your feet with his terrifying terminology, shake your fist defiantly as you stagger parched and blistered over the scorched earth of his arid abstractions.

This advice is not intended to be merely funny. Reading can never be a wholly passive affair. What I am suggesting is that it should be active, personal and vigorous. The author is not there in person but his words are there. Why not create him as you create the person behind the images on the TV screen? Drag him into the scene and have a real slap-down knockabout argument with him. Your pulse will quicken, your blood will circulate faster and your brain-cells will fire more rapidly. ~~The real work of reading is understanding and this demands an aggressive internal activity on your part.~~ You will then make the interesting discovery that reading, even when the book is dull and difficult, need not be tiring or boring but can be exciting and satisfying. In brief, successful reading involves attitudes and feelings.

Well, now for the seven deadlies:

First *unclearness*. This may be any of four types. You may meet:

- (i) unclear words
- (ii) unclear sentences
- (iii) unclear thoughts
- (iv) unclear intentions.

We will consider these one by one.

(i) *Unclear Words*

We could make an indefinitely long list of words which frequently fail to convey a precise and appropriate meaning, e.g. *involve*, *principle*, *character*, *absolute*, *function*. But no word, even a "nonsense" word like *jabberwocky*, is always and inevitably unclear, for the

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simple reason that if the author gives it a clear definition and sticks to the meaning he has assigned to it then no doubts arise. Hence it is never the *word* which is unclear but the *use* of the word.

But what does "use" mean? At this point you must face up to a duty which you, as a persistent reader, owe to yourself. It is the duty to build up for yourself a *philosophy of words*. For words are the missiles with which you are going to fight the battle of understanding. Don't think that the use of words is the responsibility of the author alone. You are going to be an active reader and this means a great deal of internal manipulation of words on your part. You must therefore learn the technology of these missiles. In the next chapter you will find out how to set about this.

→ For the present it is enough to point out that no word has a single meaning. We interpret words in a context of other words. As an example consider the following extract from *Teach Yourself Mechanics* (a book in this series).

"There is inherent in mass a property, not weight, which apparently offers resistance to attempts to impart motion. . . . This property of mass is called inertia. . . . The above principle is inherent in Newton's Laws of Motion."

Now a good deal could be said about this but I want to draw attention to the one word "inherent" which occurs twice in this passage. To begin with, the reader will not understand the passage at all unless he has read the paragraphs which precede it. And now he is being asked to understand two things—a *property* ("inertia") and a *law* (Newton's). He is told that the property is "in-

herent" in mass, and the principle is "inherent" in the law. Now a *property* is a physical cause of a physical effect. But a *principle* is a mental idea having logical consequences. The word "inherent" is used, first, to connect the *property of inertia* with *mass* and, second, to connect the *principle of inertia* with a *law of motion*.

Thus "inherent" is used to express both a physical connection and a logical connection. It shifts its meaning within the space of a few lines. And no definition of it is given. Its meaning in each case is settled by the context. Whatever other difficulties the reader may encounter in understanding mass and inertia it probably will not strike him that there is any particular difficulty about the word "inherent" in spite of its ambiguity. Indeed he may scarcely notice that the word has been used at all. From which we conclude that much of the work of words and contexts is performed silently. There will be more to say on this point in "The Philosophy of Words".

There is an important moral to be drawn from this: In the battle for understanding keep your eye on the target.

You could waste time waxing indignant about the ambiguity of the word "inherent" in the above passage. But, when analysed, it is seen to be harmless. It does not obstruct your understanding. There are numerous word-philosophers who waste their own time and lead everyone up the garden path looking for windmills to tilt at. They will pick out all kinds of apparent defects of language which offend their sense of linguistic propriety but which often cause no obstruction whatever to understanding. If it is understanding that you are after don't waste time getting angry with the author over faults

in the conventional use of language. Leave that to the critics. You don't refuse to buy sugar from your grocer because he has a wart on his nose.

It does not matter about a word having more than one meaning so long as each meaning is clear from the context, and so long as any consequences drawn from these meanings take account of any changes. But this influence of context often has the effect of requiring the reader *to delay his expectation of understanding* for several paragraphs, or even for several pages. And he may have to read a passage several times over. That is part of the battle.

Thus the recipe for dealing with unclear words is to suspend judgment and read on. If the meaning does not become clear within a page or two it may be worth while to look up the word in the index of the book (if it has one) and read the context of the other occurrences of the word. Somewhere the author may have committed himself to a definition. You may have already met it but forgotten it. Or you may have misinterpreted it because you had some other meaning more insistently in mind, like the schoolboy who spent 3s. 6d. on a book called *Advice to Young Mothers* and was disappointed to find that it was all about babies. He was a collector of butterflies and moths.

Some authors are worse than others and you may meet unclear words which never become clear throughout the book. The dictionary may help but don't expect a pocket dictionary to give you all the answers. If it is an important word used in an exceptional way you may be driven to the Reference Library to look it up in a really substantial dictionary or an encyclopædia. On the other

hand you may find that shrewd guesswork can give you the answer.

(ii) *Unclear sentences*

There are plenty of sentences, favoured by the joke makers, in which unclearness gives rise to comic ambiguities ("She could hear him blowing his nose on the doormat.") These are usually harmless since the intention is clear enough. But textbooks abound in sentences which are thoroughly obscure. The first thing to decide is whether the sentence in question is important. If not then it is best to skip it. But if it seems to deal with something substantial try to see it in relation to the sentences before and after it. These may give important clues. Or try reading it aloud several times. Try to paraphrase it. If it is a long sentence try to break it down into parts. The obscurity may be due to one or two words whose meaning is uncertain or to the complexity of the sentence structure. Subordinate clauses, relative pronouns, verbs separated from their subjects, can all give rise to obscurity of meaning. It does sometimes happen that the structure of the sentence is simply wrong but more often it is clumsy without its grammar being technically at fault. Here is an example:

"Koenig has also shown that visual acuity for black objects upon white, red and green backgrounds, respectively, is substantially the same and about twice as great as it is for blue backgrounds."*

One blinks on reading this and wonders how it can be "substantially the same" and yet "about twice as great".

* P. 148, *The Science of Seeing*, by Luchiesh & Moss, London, Macmillan 1937.

A second reading shows that "same" refers to white, red and green and that the acuity here is twice as great as against blue. There is nothing technically wrong with the sentence but it could be more clearly and simply constructed.

You can score off the author by taking such a sentence and reconstructing it yourself in clearer form. The effort of thinking it out will reinforce your understanding. The boost to your morale at having done better than the author will reinforce your memory.

(iii) *Unclear Thoughts*

A sentence may be perfectly clear as a sentence and yet convey an unclear thought. If you are merely reading in order to remember you may fail to see that the thought is unclear. But if you are reading in order to understand then you must be constantly on the alert. For an unclear thought which is expressed in clear language may beguile you into *thinking* that you have understood.

As an example of this let us consider the following sample from a best-seller of a generation ago: *The Universe Around Us* by the late Sir James Jeans, who in spite of his mathematical brilliance was guilty of more than a little muddled thinking (as Susan Stebbing scintillatingly showed in her *Philosophy and the Physicists*). The following example is not a matter of philosophy but rather a facetious juggling with words and physical ideas. It is in the final chapter on "Beginnings and Endings". After dealing with various possible disasters which might bring the world to an end Jeans says: "A danger remains which cannot be so lightly dismissed . . . the sun is a main-sequence star, and is

moreover very near to the left-hand edge of the main sequence in the Russell diagram. Beyond this edge is a region of the diagram which is completely untenanted by stars . . . the danger lies in the fact that the sun is already perilously near to the left-hand edge of the main-sequence." He goes on to explain that a reduction of a mere three per cent in the sun's luminosity would cause it to shrink to a white dwarf. "The sun is in, or is not far from, a precarious state in which stars are liable to begin to shrink and in so doing to reduce their radiation to a tiny fraction of that at present emitted by the sun. The shrinkage of the sun to this state would transform our oceans into ice and our atmosphere into liquid air; it seems impossible that terrestrial life could survive." Cor! It fair makes you shiver, don't it? But when Sir James goes on to point out that "a three per cent decrease in the sun's luminosity can hardly occur in less than about 150,000 million years" (which is about thirty times its present age) we begin to wonder what the exercise is in aid of. What possible significance is there in such words as "danger" and "precarious"? Why does he set up a bogey only to demolish it in the next calculation?

There seem here to be two unclear thoughts. There is a confusion between nearness in space and nearness in time. And there is a confusion between symbol and reality. The Russell diagram is a symbolic representation, a graph in fact, in which the relation between colour (which is a measure of temperature) is plotted against luminosity of a large number of stars. The fact that the point representing the sun is near the edge of the main sequence conjures up a vision of a car heading for

the edge of a precipice. But it is not moving in that direction and the danger is illusory.

Perhaps Jeans was only scarifying us in order to make his final message more exhilarating: "Looked at in terms of space, the message of astronomy is at best one of melancholy grandeur and oppressive vastness. Looked at in terms of time, it becomes one of almost endless possibility and hope." You pay your money and you take your choice.

This example is not chosen merely to poke fun at one who can no longer answer and who, apart from the ambiguous intentions of his popular works, certainly made fundamental contributions to astronomy. It is chosen rather to point out the need for looking out for these two confusions which are all too prevalent in topics having a mathematical basis, viz. the confusion between symbol and reality and the confusion between space and time. It is often in simple prepositions such as the word "near" that the confusion is embedded. Our language makes its prepositions do too many jobs. If authors were compelled to distinguish, e.g. by writing near (sy), near (re), near (sp), near (ti), between symbol, reality, space and time, these unclear thoughts would occur less frequently. The example also serves to counteract the myth that a training in mathematics is a sure recipe for clear thinking. Those who live largely in a homogeneous world of symbolism are, if anything, less likely to make distinctions which are obvious enough to those who inhabit the heterogeneous world of real things. A training in the making of genuine distinctions is a better recipe for clear thinking than a training in the solution of equations.

(iv) *Unclear Intentions*

There are many books in which one can find no serious fault with the terminology, nor with the sentence construction, nor even with the thought, and yet one experiences a growing uneasiness in reading them. This uneasiness is not always put into words but if it were it might be expressed thus: "Where am I getting through reading this book, and where does the author *intend* me to get?" If no clear answer can be found to these questions the author is guilty of the sin of *unclear intentions*. Writing a book is an act and if the act is to be effective it must be purposive. And the purpose should be clearly defined.

As an example of unclear intention let us consider that old classic of elementary science (or is it elementary applied mathematics?), viz. Loney's *Elements of Hydrostatics*. I quote from an ancient edition of 1913—it is long enough ago to cause no offence but the fault exemplified is perennial. Consider Loney's definition of a "Perfect Fluid" (page 2):

"Perfect Fluid. Def. A perfect fluid is a substance such that its shape can be altered by any tangential force, however small, if applied long enough, of which portions can be easily separated from the rest of the mass, and between different portions of which there is no tangential, i.e. rubbing, force of the nature of friction. The difference between a perfect fluid and water is chiefly seen in the case of the motion of the water.

"For example, if we set water revolving in a cup, the frictional resistances between the water and the cup and between different portions of the water soon reduce it to

rest. When water is at rest it practically is equivalent to a perfect fluid."

Now in examining this definition it is only fair to consider it in the context of the rest of the book. Is the book intended to be a mathematical exposition of the theoretical behaviour of an abstract entity, viz. the Perfect Fluid? On looking through the book we find frequent mention not only of unspecified liquids and gases but of water, oil, mercury, air, hydrogen and so on. The mathematical theorems all refer to Perfect Fluids but the examples frequently refer to physical liquids and gases.

Well, perhaps the behaviour of these substances is sufficiently close to the Perfect Fluid to justify the use of theorems based on this Fluid. But no. Loney himself points out that water is neither frictionless nor incompressible. What he claims is that water *at rest* is "practically equivalent to a perfect fluid". But although the book is on Hydrostatics, which implies *water at rest*, when we examine the phenomena dealt with we find statements about "water finding its own level", about liquids being mixed, being poured or pumped, about bodies sinking in water, about diving-bells and all sorts of topics in which fluids are in *motion*.

Now there is a perfectly good answer to this objection, viz. that although these phenomena involve motion in time the final state of equilibrium is timeless, and since the forces due to the imperfections of real fluids only operate during motion the mathematics of the Perfect Fluid hold good for real fluids at rest. This answer is not quite as watertight—if the term may be allowed—as it appears but let that pass. The point is that if the mathe-

matics of the Perfect Fluid are really found in practice to hold good for real fluids at rest without any need for correction then the author should have made this clear at the outset. We should know then that we have a book on the mathematics of the Perfect Fluid which is applicable to real fluids so long as the time factor is left out. Otherwise we are left with the haunting uncertainty as to how great a margin of error will arise in applying these formulae in practice? Will my balloon burst or my ship sink?

This example of unclearness of intention is not an isolated one. When we come on to Hydrodynamics we can no longer ignore the time factor. Hydraulic and aeronautical engineers know from hard experience that viscosity, surface tension, turbulence, and other properties of real fluids make nonsense of a great deal of mathematical treatment. But a subject called "Applied Mathematics" continues to be widely taught on the implicit assumption that the mathematician can tell the physicist how real matter will behave. It should be called "The Mathematics of Imaginary Substances" and then we should know where we were.

The general moral of this is that the author may be regarded as taking the reader on a journey and the reader has the right to know where he is being taken. Otherwise he may find himself being taken up the garden path.

Our second deadly difficulty is *unfamiliarity*. Of course this is entirely a relative matter. What is familiar to one reader is unfamiliar to another, and what is unfamiliar at one time may be familiar a few years later. As with unclearness this difficulty can appear in words, in sentence forms, in thoughts and in intentions. In the

main it results from a deficiency in the reader rather than from a fault in the writer, though of course there *are* writers who deliberately employ unfamiliar words, etc., i.e. words likely to be known only to a small minority of readers, or if not deliberately then through ignorance of common vocabulary limitations.

Before grumbling too fiercely when faced with something unfamiliar you should pause to ask yourself: "Why am I reading at all?" You do not read what you already know (except perhaps for revision). Surely your main purpose in reading is to become familiar with something you don't know. But of course there is a distinction between the unfamiliarity of the subject matter, which is inevitable and proper and unfamiliarity in the language used to convey it. The author can communicate with you only by means of *your* vocabulary. He may, and usually should, increase your vocabulary a little by introducing new words but these should always be defined. The unfamiliar words which cause difficulty are those which are slipped in without any explanation.

Well there is nothing fatal about an unfamiliar word. The very fact that you are a reader implies that you are a self-educator. Every serious reader should have a good dictionary at hand. Take unfamiliarity as a challenge. It can extend your vocabulary. Moreover it does this in a manner which is more profitable than merely learning lists of new words, for you see the word in a *context*. Many people seem to go through life on the assumption that their vocabulary on leaving school is sufficient to see them through life. The self-educator will welcome every opportunity to extend his vocabulary.

The same considerations apply to unfamiliar sentence

structures but here the remedy is not so easy since we have no dictionary of sentences. Some structures can be recognised by Latinists as due to the classical education of the author. This is less common today than in the hey-day of classical education when it was deemed a virtue to impose Latin forms on English sentences. Today there is a regrettable tendency in scientific literature to impose German forms on English sentences—doubtless this is due to the large numbers of scientists driven out of Europe by Hitler and settling in England and America where they have had to express themselves in a new language. It is easier to learn the vocabulary than the structure of a new language.

But quite apart from extraneous influences the kind of *thought* which is characteristic of any particular branch of knowledge tends to beget its own forms of sentence structure. An involved subject like economics, for example, whose concepts take account of a multiplicity of factors all acting together, tends to yield sentences like this:

“Attempts at self-regulation of production in certain industries, to prevent excessive supplies at unremunerative prices, and further attempts at Government regulation with the same object, through the great disparity between potential production and the actual working of the economic machine under the conditions of a crisis of confidence, have brought ‘planning’ to the forefront” (Sir Josiah Stamp in *The March of Science*, 1937).

Or again, from the same book, in a chapter on Physiology:

“There is a reciprocal relation between the magnitude of the e.m.f. and the time during which it has to act which, for short times, is such that the total quantity of electricity required to initiate an impulse is constant.”

What we must note here is that these sentences are expressing concepts which could more simply be expressed in mathematical form. Our grammar evolved in response to daily needs and in the past the ideas of daily life were mostly non-mathematical. Science is now imposing on language an enormous number of new concepts which are essentially mathematical in structure. Our common grammar is ill-adapted to express these structures in simple sentence patterns.

It may well be that science will find it necessary to evolve its own grammar. If all scientific communication were carried out in writing it could be expressed more and more in mathematical forms. But the spoken word has a vital part to play and it is not easy to *talk* mathematics. And so a kind of hybrid grammar is taking shape, still paying lip service to traditional forms but expressing relationships which are mathematical.

In order to read modern books intelligently the reader thus needs to be aware of the problems of expression which science, with its continual novelty of thought, is forever posing to the writer. The reader must be prepared to do his share of the work in reading between the lines and trying to see through the conventional grammar to the underlying mathematical concepts. And he must bear in mind that a concept may be mathematical without being directly translatable into an equation. The

sentence from Sir Josiah Stamp could hardly be put into an equation but it expresses quantitative relations even if some of the quantities are unknown.

Probably the trickiest unfamiliarity is that of intention. An author, through his writing, is trying to do something to your mind. He may be simply trying to *inform* it. But he may also be trying to *form* it. He may want to turn it in a new direction, to open it out, to shake it up, to give it new powers. And until he has succeeded you cannot, in the nature of the case, appreciate what he is trying to do. His intention is necessarily unfamiliar. The techniques he adopts to fulfil his intention will puzzle you. But the very fact that you have bought or borrowed his book must mean that you have good reason for wanting to put your mind at his disposal.

Of course it may dawn on you after a while that he is trying to turn your mind in a direction which you don't want it to take. You may have mistaken your man. He may be out for propaganda instead of education. Or he may be trying to mystify you, as Sir James Jeans sometimes did. Or, of course, it can happen that the author himself does not know what he is trying to do, either because he has no clear intention or because it is an unconscious one.

The relation between reader and writer is a peculiar one. In your own interests you should pay attention to it, and over and above the effort of comprehension required to the subject matter it is worth while to make a further effort to discern the author's purpose and to ask—what is its relation to *your* purpose?

Incompleteness, our third difficulty, together with ambiguity and heaviness, our fourth and fifth, are all

obvious enough sources of trouble and need not occupy so much of the discussion. Incompleteness is not, of course, to be judged by reference to some impossible ideal. No book can ever exhaust a subject. But it can be said to have done its job completely if it does what it set out to do. If its aim is to give the reader an understanding of the design of turbines or the law relating to children then the author should have formulated the *level* of understanding at which he is aiming and the reader should be satisfied that this is the level he requires. Of course this is not always an easy matter. An examination in the offing can help greatly in making aims more precise—indeed this is one of the practical justifications for the examination system, viz. that it serves to define the aims of instruction. But authors are sometimes satisfied with a literal completeness which fails to give psychological completeness. Mathematical authors are often among the worst offenders in this respect. In presenting such a topic as Imaginary Quantities and Complex Numbers it is *not* enough for the (usually) adolescent student, who often has quite a capacity for getting excited about novel mathematical ideas, to be given merely a formal exposition showing how these strange symbols work. A short historical account of how they were discovered, why they were called “imaginary” and how they became important in Electrical Engineering, need not occupy more than a page or two but, if well done, can make them live.

Again, many books are verbally complete but deficient in illustrations. Or a subject may contain a good many technical terms requiring a glossary at the end. Chapters require summaries but do not always have them.

Diagrams may be inadequately labelled. If I were writing for authors I could go on to quite a catalogue of common failings. But what can the reader do? He can set himself to make up for the deficiencies of the writer. There are plenty of illustrated encyclopaedias in libraries. There are histories of science and mathematics. You can make your own summaries and compile your own glossary. In fact the more the author makes you work the more you will get out of it. This does not excuse his incompleteness but it shows that you can turn it to your own advantage. It makes you an *active* reader.

Similarly with ambiguity. A dictionary will often help. Or where there are two alternative meanings, either of which might initially appear to make sense, follow them both through and see which fits best in later contexts.

But ambiguity is a feature of language which requires the whole philosophy of words to elucidate. Professor William Empson, when quite a young man, wrote his *Seven Types of Ambiguity* in which he showed that ambiguity is neither simple nor necessarily a bad thing. In poetry it is indispensable. If you listen to a bell tolling you will soon detect two, three or even more notes in addition to the actual pitch of the bell. It would be naïve to say—why couldn't these bell-makers decide which note they wanted to sound and stick to that. In the first place it is physically impossible to avoid overtones. In the second place there is no sound so dull as a pure tone. The art of the poet, and indeed of any writer with a feeling for words lies in his sensitiveness to the overtones of his language and his awareness of the

interplay of reverberations which these overtones can produce in the mind of the reader. *You can use your response to ambiguity to explore the resources of your own mind.*

Heaviness is the most unattractive of difficulties. At its worst it betokens sheer incompetence and unless there is some compelling reason for reading that particular author it is better to look for another author on the same subject. But heaviness may be more apparent than real. Long words and long sentences *look* heavy, but read on awhile and you may find a rolling rhythm about them, a sea-swell of hidden feeling which puts you in motion, and carries you into the author's mind. Try reading it aloud and form mental pictures of what the words are telling you. You may find that though long in print, each represents quite a sharp schema. So long as they are not unfamiliar as well as heavy you may soon find yourself skipping along from one blip of thought to the next with no feeling of heaviness at all.

Scientific journals often look appallingly heavy. Yet working scientists in search of the latest news on their speciality can skip through pages of long words at an incredible rate. A car is not exactly a light object but you can run your eye over a car park with rapid recognition of all the makes if you are knowledgeable about cars. What I am saying is that the length of a word is entirely unimportant. You hardly ever read a word letter by letter. You take it in as a whole. Heaviness is not a matter of length of words or even of length of sentences. It is either due to lack of art in the writer or to lack of rhythmic sense in yourself.

Finally, and briefly, before this chapter lengthens

inordinately, we must look at *complexity* and *abstractness*. Complex words are not necessarily long words. The word "norm" is short but its meaning is far from simple. Every subject has its own stock of key words, not necessarily complex in appearance, but with meanings which are intrinsic to the whole theory of the subject and often having quite peculiar implications. The word "stress" has been current in medical writings for some years. It is short enough but it embodies a complex theory of body-mind relations. You may find that it takes more than one reading of a book to determine all the key words and some passages may have to be read over and over again, pensively, to come to grips with the full complexity of thought of these words. It is worth the effort because it is these words which both illuminate and unify the whole thought of the book.

Lastly *abstractness*, and this goes to the heart of our philosophy. The essential unit of mind is the schema. The most abstract words lead you to the most general (and hence the most *powerful*) of the schemas. Look diligently through the book for all the most abstract words. These are your slugs of uranium in which your mental nuclear pile will generate its power. The precious U235 may be mixed up with a good deal of superfluous U238 (or, if that means nothing, the pearl may be embedded in a very fat oyster) but it is true wealth and worth the struggle.

These essential abstractions are not always identical with the complex key words discussed above. The latter may represent elaborate networks of fact. Abstractions are refinements which may be of fundamental simplicity like *quantity*, or *change*, *law*, *proposition*, *form*. Your

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task, as a reader, is to find from the context, what these words mean to the author, whether he is using them consistently and how they control the thought expressed in the text. These abstractions constitute the citadel of his homeland. When you have penetrated to this your battle of understanding is won.

EIGHT

THE PHILOSOPHY OF LEARNING

THE descriptions given by philosophers of their own objectives and their own procedures have seldom squared with their actual results of their actual manners of working. They have promised, for example, to give an account of the World as a Whole, and to arrive at this account by some process of synoptic contemplation. In fact they have practised a highly proprietary brand of haggling, and their results, though much more valuable than the promised Darien-panorama could have been, have not been in any obvious respects like such a panorama.

*GILBERT RYLE, *The Concept of Mind**

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chemistry and physiology will enable you to understand breathing. But reading is a good deal more complex than breathing and there is still a lot that we don't know about it. But at least you should start wondering at the sheer miracle of the thing. For wonder is the necessary prelude to understanding.

You have probably been reading since you were about six and you will now have amassed a vocabulary of some tens of thousands of words. Nearly all those words have long histories going back hundreds or even thousands of years. You may know little or nothing of these histories (you would have to be a philologist to know many of them) and yet those histories play an important part in your use of the words. How come? Most of your present vocabulary was already in use when you were born. It belongs to the community in which you live. It has become part of your mind through countless speech transactions. You have come to use words in the way other people use them. They learned them in the same way and these incessant word transactions have been in progress since the beginnings of language. Thus the history of language imposes itself on your mind, just as the handshake, the nod, the salute, the grimace and other gestures have imposed themselves on your behaviour.

Now this may seem obvious enough but it has an important consequence. A glance at the newspaper will assure you that man is far from being a rational creature, if you hadn't already noticed the fact. And he never has been. History is the record of his absurdities. And it is in man's past behaviour that language has evolved, to enable him to share his absurdities and to convince him-

self that they are pearls of wisdom. Thus language itself is shot through with man's absurdity.

Grammarians have tried to tidy up language, to parcel it up into neat paradigms and make it look as if it had all been designed by logicians for strictly rational purposes. This is why grammar strikes most intelligent schoolboys as the biggest absurdity of the lot. They find that Shakespeare can get away with "But me no buts" and they wonder who makes the rules.

The bearing of all this on our present theme is that although it is a good thing to keep yourself in a state of simmering anger against the author whose words you are struggling to interpret (in order to keep yourself awake) you can also spare him a morsel of pity for having the impossible task of communicating what is presumably rational knowledge through such an irrational medium as words. The wonder is, as Dr. Samuel Johnson said, I think, about women preaching sermons, not that it is done well but that it is done at all.

Words, then, are wonderful things but they are not rational things. And yet they can be put together to evoke rational meanings. But from what I have said above you will realise that it is in your own mind that these rational meanings must take shape. Thus unless you yourself are ready to think rationally about what you are reading the author can't get through. This means that you and he should think of yourselves as having a job to do together, a job of rational communication through an irrational medium.

Of course the words "rational" and "irrational" beg several questions and we ought to clear this up. If your house is awkward to get at and you are writing to a friend

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telling him how to reach you it is usually best to draw a sketch. You *map out* the route for him. The route forms a certain pattern in space and you draw a similar pattern on the space of a piece of paper.

Now this is very sensible because the thing you are talking about (the route) is allowed, as it were, to speak for itself. In other words it imposes its own pattern on your act of communication (i.e. the drawing of the sketch). Next to taking your friend on foot along the route you could hardly convey its pattern more directly. We can say, then, that you are using pencil and paper in a "rational" way to convey meaning. Man's absurdities don't get in the way to obscure the meaning. We can say, then, that if a communication is map-like it is rational.

If a meteorologist wants to discuss last year's weather with you he might draw a graph showing the ups and downs of temperature, rainfall, etc. This is not a map in quite the sense used above but so long as it is agreed that the horizontal line marks the dates and the vertical, say, the temperature, then the behaviour of the weather imposes itself on the shape of the graph. The graph is a language constructed according to a consistent rule. Absurdity does not creep in (or rather it can be kept out, though absurd graphs are not unknown). Thus here again we have a rational form of communication. So we have two rational forms of communication, map-like and graph-like. But of course not everything can be mapped or graphed. For most purposes we resort to words, as in ordinary language, or to symbols as in mathematics. Neither words nor symbols are at all *like* the things they represent, nor are they based on any consistent rule of construction like a graph. There is no

inherent reason why the animal which supplies our milk should be represented by the word "cow" rather than by any other sign. There is no inherent reason why "=" should stand for "equals". Words and symbols are, to all intents and purposes arbitrary. This does not make them absurd but it does mean that they are not rationally derived from the things they stand for. Thus they all have to be learnt. They cannot be deduced by reason.

We learn our words through thousands of experiences. We hear and say them over and over again in many different contexts. Many of these experiences are shared with other people and thus there is a *tendency* for us to use words in ways similar to those in which other people use them. But it is *only* a tendency. Our experiences, though overlapping, are never identical. For the most part we do not use words with strict reference to dictionary definitions in mind but rather as they come to us out of a mass of associated experiences. They are not like coins with fixed values.

We say that something is "rational" if it can be analysed in terms of logic. But logic depends essentially on the use of words, or other signs, having a definite and unchanging meaning. Thus the scope of logic is really very restricted. For most human discourse logic is quite inadequate. We must not make demands on language which its very nature unfits it to fulfil.

Now where does this lead us? The purpose of this discussion is to encourage a rational approach to reading. I have suggested that the writer is inevitably handicapped by having to try to convey rational meanings through an irrational medium. You, the reader, will handicap yourself in either or both of two ways if you fail to

appreciate the writer's difficulty. Either you get cross with the author for irrationalities which belong to the medium of words and which are not his fault at all. Or you get cross with yourself for failing to see rationality in the words when there is in fact, none to see. What you have to appreciate is that both you and the author are concerned with *meanings*. Language is a kind of smoky and crinkly glass through which he is trying to signal to you. Your task is to see *through* the language to the meanings. In other words don't be fussy about the words but concentrate on the meanings. It is the author's business to fuss about words.

This principle, however, must not be pressed too far. Given that you are reading in order, some time, to answer questions on what you have learnt, you will need the words in order to frame your answers. The point is that for *understanding* you must see through the words to the meanings, but for *memory* you must pick up the words again in order to preserve a form of expression. And of course in some subjects words are themselves the object of study, e.g. philology or a foreign language. It is important to appreciate what a very complex thing a word is.

It will be useful at this point to turn to the views of one of the principal authorities on the theory of the schema—Sir Russell Brain, the well-known neurologist. At first the following quotation may seem out of place in a chapter on the *philosophy* of words, but, as the reference to Kant shows, the schema was originally a philosophical concept and even today logic is as important in developing the theory of the schema as physiology or psychology.

“I believe that one form of physiological organisation,

which, borrowing both the idea and the term from Kant, I have called the schema, plays a predominant part in the speech functions of the brain. Let me illustrate this by explaining its simplest function, namely, the part which it plays in the understanding of the meaning of a word. Let me further limit it to the meaning of a spoken word.

“A single word may be uttered in an unlimited number of ways, which differ from each other in pitch and volume to say nothing of the differences produced by local dialect. Yet we are so accustomed to regarding all these variations as the same word that we do not realise what an achievement it is on the part of the nervous system that we should be able to do so. The range of the human voice extends over more than three octaves, and the frequency of the sound waves which compose words at the two ends of the range differs enormously. Correspondingly, different parts of the cochlea are stimulated, the auditory nerves respond differently, and it has been shown that the resulting nerve impulses reach different points of the auditory cerebral cortex. What process in the brain enables us to identify these differing incoming impulses with the same word? The answer is that as we learn to speak we learn to attend physiologically to the pattern of sounds which are characteristic of a particular word however it may be uttered, and in order that we may do this there must exist in the nervous system a physiological disposition for each word which I have called an auditory word-schema. This schema is, as it were, a resonator which reacts to the pattern structure of an individual word, and it is thus an essential link between a word and its meaning, for the varying stimuli and the varying peripheral reactions to them which

represent a word can evoke that word's meaning only by evoking a reaction in the corresponding auditory word-schema. But this is only the beginning of the story. A word may have many meanings, and in a given instance its particular meaning may be determined by the other words with which it is associated in a sentence. In this, temporal sequence and relational words are all-important. Hence, in speech, the nervous system has to deal with sentence-schemas as well as word-schemas.

"In the case of a literate person there is a further complication. When we learn to read and write we learn to associate in a complicated fashion visual symbols with the sounds of words. This involves the creation of visual word-schemas and enriches the auditory word-schemas which previously reacted only to the sound of words spoken, but now comes through the visual word-schema to react also to the signs of words written or printed, and may now be termed the central word-schema. Let me emphasise that a word-schema is a physiological disposition. When we hear someone speak we are conscious of the sounds of the words he utters, a particular group of auditory sensa, we are not conscious of the corresponding word-schemas. The physiological word-schema thus corresponds to the abstract notion of a word as a linguistic unit."

From this we see two things. The first is that not only are our concepts embodied in schemas but the very words we use to explain our concepts are themselves embodied in schemas. The second is that these schemas, even for a simple word like "dog" are both complex and systematic. The central word-schema which gives access to the schema of *meaning* on the one side gives

access to the pathways of perception, and on the other, to action, i.e. to the seeing, the hearing, the saying and the writing of the word "dog". The more often all four of these pathways are trodden the sharper and firmer the central schema becomes.

Thus the reader can apply this philosophy of words to his own learning. He will not rest content with a single pathway but will tread the ground in all directions, sharpening and strengthening his newly constructed schemas.

2. *The Philosophy of Knowledge*

The serious reader, it may be assumed, has a thirst for knowledge. It is as well for him to have some idea of the nature of the thing for which he thirsts. It is only philosophy which claims to deal with the nature of things. Science deals only with their structure and behaviour. Philosophers differ widely in their views on the nature of knowledge. The reader might well begin with Bertrand Russell's *Human Knowledge: its Scope and Limits*. If it does not answer all his questions it will at least open up many new vistas of thought. Russell says there are many different kinds of knowledge, that knowledge is a matter of degree and "that all human knowledge is uncertain, inexact and partial". It is comforting to the present author to find that Russell supports, by implication, the view given in Chapter Six concerning the importance of *conditioning* as a forerunner of knowledge. For he defines knowledge as "a sub-class of true beliefs". And he says "Animal habit is essential to the understanding of the psychology and biological origin of general beliefs". Finally when there is a sequence of

events leading to the conditioning of an animal through an event A being repeatedly followed by an event B, Russell says "I shall say that an animal 'knows' the general proposition A is usually followed by B".

We have seen that conditioning processes set up schemas and that a schema is a pattern of brain-activity. But this is not enough to define "knowledge" because there may be many patterns of brain-activity which are not schemas. What is it that distinguishes a schema from other patterns? Is a schema in some way *like* the thing of which it gives knowledge? Is the schema for an elephant like an elephant? Possibly it is, a little, but even if this could be demonstrated by some ingenious feat of electro-physiology this would not take us very far. Man does not live by elephants alone. He lives also by truth, goodness and beauty and also by verbs and prepositions and quadratic equations. It is difficult to attach any meaning to the suggestion that our schema for a preposition is *like* a preposition.

Professor Stephen Toulmin, in *The Philosophy of Science* has described the physicist as "a surveyor of phenomena" and has worked out a thorough-going analogy between theories and maps. Now if a theory is in some degree true it may to that extent be called a piece of knowledge. Knowledge then is something like a map. A map bears very little resemblance to the territory which it represents but may be a very practical guide to that territory. I have distinguished in the preceding section between maps and graphs but I think Professor Toulmin would class them together. A graph is still less like the thing which it represents—a rainfall graph is not at all like rain but it tells us something important

about the rain. Thus the essential property of a map is not so much any formal similarity which it bears to what it represents but rather the fact that it acts as a *guide* to that territory.

We may say then that we have knowledge of a thing when we have a schema which acts as a guide to that thing. Knowledge, like faith, must be shown through works. Thus knowledge is not a static quantity but a growing system of schemas. Our actions react on our knowledge, correcting and reinforcing it, rather as if the map-maker, every time he walked over the territory added a bit more to his map.

The implication of this principle to the reader should be obvious. Never be content with merely reading. Take action of some kind. Put your knowledge to the test.

But this relation between knowledge and action also has other implications. These were first thoroughly explored, rather surprisingly, in the design of guided missiles. The action of a guided missile is to seek out its target and then explode. To reach its target, which may be a moving aeroplane, it must gain "knowledge" of the changing position of its prey. It must have "eyes" or "ears", i.e. organs sensitive to radiation. The messages of these organs must be transmitted to the controlling mechanism so as to steer the missile in the desired direction. As this may cause it to swing too far in the other direction the missile must also have organs for giving it information about its own motion. For its success in reaching its target depends on a correct relation of its own motion to the motion of its target. And all this applies equally to schoolboys playing "Tig" or to a dog chasing a rabbit.

The information concerning its own movements, whether in a machine or an animal, is known as "feedback" and the science which deals with these phenomena of control and feedback was called "Cybernetics" by the eminent mathematician Norbert Wiener who laid the foundations of this new science. It was soon found to have far-reaching repercussions not only on purely physical problems but also in physiology, psychology, sociology and even philosophy.

We have not only machines which can steer themselves but machines which can calculate, store information, play games, "learn by experience", translate languages (after a fashion) and even, in some sense, "think". That so many functions hitherto thought of as distinctively human activities should be performed by machines is surely a challenge to philosophy. Dr. Grey Walter, of the Burden Neurological Institute, so well known for his mechanical tortoises (which really are pets when you get to know them), has compared the human brain to a machine (*The Brain as a Machine*, Proceedings of the Royal Society of Medicine, Vol. 50, 1957). This is challenging because machines are man-made whereas the only sense in which the brain can be said to be "made" is the same as the sense in "God made the universe".

Man, using his brain to define certain things which his brain can do, makes machines which can do these things. This is intrinsically no more remarkable (though technically more complex) than using his hands to make tools to do the things which his hands can do. Philosophy can rest assured that the activity of the brain will always transcend the activities which it can define. Philosophers

need not resist this cybernetic approach to the study of the brain. It is not a dogma and no one could agree more with Russell's assertion that "all human knowledge is uncertain, inexact and partial" than Grey Walter. These models are instruments in the search for truth, as is the theory of the schema itself.

The concept of the schema so extensively used in this book as a convenience of exposition, has no orthodoxy, for it has been adopted often independently by physiologists, psychologists and philosophers of widely differing outlook. And indeed orthodoxy would kill it for there is no terminus in the quest for truth. One of the most systematic of its philosophical exponents, the late Ernst Cassirer (a philosopher as widely different from Bertrand Russell as any philosopher could be) agrees with him in this, and this chapter can have no more fitting conclusion than Cassirer's own words (in *The Philosophy of Symbolic Forms*, Vol 3). "Absolute trust in the reality of things begins to be shaken as the problem of truth enters upon the scene. The moment man ceases merely to live in and with reality and demands a knowledge of this reality, he moves into a new and fundamentally different relation to it. At first, to be sure, the question of truth seems to apply only to particular parts and not to the whole of reality. Within this whole different strata of validity begin to be marked off, reality seems to separate sharply from appearance. But it lies in the very nature of the problem of truth that once it arises it never comes to rest. The concept of truth conceals an immanent dialectic that drives it inexorably forward, forever extending its limits. . . ."

NINE

THE ORGANISATION OF KNOWLEDGE

“WE cannot regard knowledge as simply the accumulation of information in a stockpile, even though all messages that are received by the brain may leave some sort of deposit there. Knowledge must itself be regarded as a structure, a very complex and frequently quite loose pattern, almost like an enormous molecule, with its parts connected in various ways by ties of varying degrees of strength.”

KENNETH BOULDING “Notes on the Information Concept.” Explorations, 1955

NINE

THE ORGANISATION OF KNOWLEDGE

STANDING in a large library and gazing round at row upon row of the evidences of man's efforts can be humiliating, depressing, even alarming. And yet the librarians, who spend their lives amidst this constant reminder of their individual limitations, seem quietly confident, cheerful and friendly. In a bustling, aggressive, uneasy world they stand out as guardians of a sanctuary. But this sanctuary is no solemn temple of immobile brooding. Its quietness is more akin to the smooth hum of a power station. It is worth taking time off from your own anxious quest for learning to look round and consider the scene with a little imagination.

If you have stood on a roof during an air-raid and watched a large public library blazing and, amidst all the other destruction, felt the peculiar wantonness of this particular set-back to man's civilising impulse, you will begin to ponder on the strange power which is the daily business of these quiet functionaries. And you may begin

to see your own efforts at learning in a perspective which gives it a new significance.

We are getting used to the idea that in the new nuclear power stations the consumption of one nuclear fuel may not only produce power for immediate use but may also breed a second type of fuel. The library is an even more remarkable transformer of energy for the "fuel" which goes into it, in the form of books and journals, not only gives out a steady flow of power through all its readers, many of whom produce further books themselves; it remains itself intact, preserving its energy undiminished. This is the unique property of organised and recorded knowledge.

Look round not only at the books but at the readers. Speculate on their interests and their purposes. That woman is looking for a cookery-book to enable her to give more variety to her family dietary. That pimply youth has just found that poetry has meaning for him. That girl in slacks with the black droopy locks is devouring books on play-production. That purposive young father is finding how to decorate his house. That sedate spinster, who sits on a social welfare committee, is mastering the subject of prostitution. That lad with the black finger-nails is working for an examination in motor engineering. That schoolboy is absorbed in Roman Archaeology. That tired-looking civil servant is working his way through the sagas of C. P. Snow. Words, words, words, flowing out from the library, into countless minds, opening them to new actions, new experiences, new powers, new worlds. And these catalysts of brain-action, having done their work, return to the library unchanged, ready to do it again as often as needed. And

as a result homes are made more attractive, careers are made more effective, committees are made more productive, time is more meaningfully spent, the oceans and generations are bridged, and the mind of civilisation, triumphing over space, time and matter, becomes ever more articulate and purposive. This is the power-transformation in which you are participating every time you open a book.

The quiet effectiveness of a typical public library rests on a system of expectations. The readers expect to be able to find more or less what they want more or less on shelves appropriately labelled. The librarians expect a certain range and frequency of interest among their readers and a certain pattern of subject matter in the annual output from the publishing houses. And the publishers expect a certain flow of production from the authors and a certain pattern of demand from the public. But these are all variable factors, and expectations are not certainties. Fads and fashions, public events and scientific enterprise, discoveries and disasters, are forever twisting and churning the flow of words. Behind the quiet hum of the power house an incessant and anxious process of selection and decision goes on. For books are not only mental stimuli, they are physical objects which have to be paid for, transported and stored. The unprecedented expansion of human knowledge in the past half century has resulted in a production of books and journals on a scale which is already beginning to alarm the librarians. As libraries get bigger more and more time is spent simply walking and searching. And, as the level of articulate demand for specialised subjects grows, the needs of the readers become more insistent and

urgent. It is not an exaggeration to say that librarianship today faces a crisis. And, since the wheels of civilisation are driven by the power of words, this is not a crisis which librarians alone can solve. Writers, publishers and readers all have to contribute to the solution. In the case of the readers it is their habits of learning, remembering and knowing which are involved. We have heard a lot in recent years about the relation of men to machines. We have given too little thought to the relation of men to books.

A crisis need not be a disaster. Faced with unprecedented difficulties some men go under but others respond by invention. The librarians are thinking about their job more radically than ever before and as a result their methods are being revolutionised. As this revolution has some bearing on the problems of learning, knowing and remembering it will not be out of place to say a little about it here. A new technology is taking shape, a technology of processing, storing and retrieving information. It is not altogether fanciful to see a certain parallelism between these three processes and the processes of learning, knowing and remembering. In both cases information is taken into a system—a library or a brain—it is held there in a classified or schematised form, and it can be made available when required. Perhaps the working of a library can throw some light on the working of the brain. When man invented the lever he was able to understand the working of the arm and leg. When he invented the pump he was able to understand the working of the heart. When he invented the electric telegraph he began to understand the working of the nerves. And now that he has invented machines for

handling information he is getting fresh insight into some of the functions of the brain.

The student who uses a library usually tends to think of his relation to the library in terms of the individual occasions on which he goes to the shelves, searches for a book, finds it, hands in his ticket at the counter and walks out with the book. If it is exactly the book that he wanted, and if the book contains exactly the information he needs, arranged in exactly the most suitable way for his needs, then he tends to take for granted all the work of the author and of the librarian in meeting his requirements. But often this is not the case. There may not happen to be a single volume which satisfies his particular needs. He may have to consult the librarian. He may need to borrow several volumes and these may be scattered in different parts of the library. In studying them he may have to select different chapters from different volumes. And all this presupposes that he can state clearly just what he is after. In such circumstances he may begin to glimpse what is meant by the "organisation of knowledge".

The author has to organise his knowledge in order to plan what he is going to write. He then has to organise his use of language in order to transfer his knowledge to paper. The mechanics and economics of printing and publishing do not concern us here. For our purpose they provide the bridge between the author and the library. In the library we find a continual inflow of books, pamphlets, journals, reports and other documents. With a few exceptions (such as the British Museum Library in this country which takes virtually everything which is published) most libraries have limited resources

one has the business of deciding what to buy. This cannot be a haphazard process and must therefore be organised.

Let us compare the process thus far with what happens to the human brain. At any given moment the environment is bombarding the brain (or rather the surface of the body) with a deafening barrage of information. It is saying, in effect, "This chair is hard and the floor has a carpet and the fire is warming you on one side and the window is cooling you on the other and one side of the room is lighter than the other and there are pictures on the wall and cars outside in the road and a train in the distance and . . ." Your skin, eyes, ears, nose and other sensory areas are all busy translating this immensely complicated stream of physical messages into patterns of nerve-impulses which stream inwards to the brain. But the brain ignores most of them. It accepts only what is relevant to the work in hand. This may be something very specific demanding great concentration, in which case by far the greater part of the information is rejected. Or you may be sitting on a bench in the park enjoying the spring and noticing as much as possible of what is going on round you. You then have a very open policy of acceptance. Or you may be in a foreign country trying to observe all the ways in which things and people differ from those at home. Your brain-policy then is to reject the familiar and to accept the unfamiliar. Obviously the brain can adopt all sorts of different policies on different occasions. In this respect it is much more versatile than any library can afford to be. My colleague Mr. Eugene Bernard is investigating the "filters" in the brain by which these policies are operated.

This selectivity of the brain is clearly of fundamental importance in the learning process. For, like a library, a brain has only limited resources. It cannot afford to take in all the information that comes its way. It would not have the power to handle it nor the accommodation to store it. It has to obey principles of economy. The effectiveness of an individual brain is not a matter of sheer physical energy but rather of adopting and following a consistent set of filtering-policies. And this is where staggeringly large individual differences appear. We are only now beginning to appreciate the principles governing the economy of the brain and this new insight is transforming our understanding of the nature of intelligence. The ability at an early age to score high on intelligence tests is a very unsafe basis for predicting the later successful use of the brain. For intelligence tests do not measure the ability to adopt effective policies for selecting information. However this is a very controversial issue and beyond the scope of our present theme. The point is that the *effective* intelligence of the individual is to some extent under his own control. By taking thought about his purposes and policies, and by observing principles of economy in his selection of information, he can give his brain a chance of functioning at its optimum.

It is not without significance that some of the most rapid advances in the technology of information-processing have been made in libraries devoted to specialist needs. Given a limited range of subject matter it is possible to analyse and organise its parts into a reasonably coherent and logical system. When information can be systematically processed modern

machine methods come into their own. This is the clue to follow in exploring the analogy between machine processes and brain processes. No machine can imitate the brain as a whole. But given a limited field of knowledge, with defined boundaries, we can draw a logical map showing the relations of the parts to one another and the way in which they constitute the whole. Machines can handle such limited wholes speedily and precisely, for mechanical and logical reasons. Many of the early experiments on human learning showed that "learning by wholes" is often more effective than "learning by parts". For example if a poem is not too long it is learnt more efficiently by going right through it a number of times rather than line by line. But the proviso that it must not be *too* long is important. The reasons for the superiority of the "whole" method are complex and there is obviously no exact parallel here with the process of storing information in a machine. There is no reason why an indefinite amount of quite miscellaneous information should not be stored on the "memory drum" of a computer, and if we are only interested in mere storage the limit is a purely mechanical one. But storage is only a means to an end. The squirrel stores nuts in autumn so that he shall not starve when spring comes. Only the miser stores merely for the pleasure of hoarding. Normal storage is for the sake of retrieval. And this is the crux of our problem both in the library and in the brain.

The squirrel buries his nuts and then goes to sleep. The librarian puts a new book on the shelf and turns his attention to other books. In a large library the handling of the books will be carried out by assistants, and the

chief librarian will see very few books himself. Thus there is no question of his *knowing* all that is in the library and where every item is located. This is important because it means that the library must function, in a sense, *unconsciously*. In other words the borrower does not depend on the chief librarian to tell him where to find what he wants. Taking the library as a whole we may say that it stores its information and forgets it, like the squirrel. But we must not pursue this analogy too far. I do not know how the squirrel sets about finding his nuts when he wakes up but I imagine that he stores a sufficient number in holes and corners near his winter nest so that when he wakes up he will be pretty sure to find food wherever he looks. This may be called a "probabilistic" method of storage and retrieval. With simple uniform needs it works well enough. All that the squirrel wants is food. The nuts may differ among themselves but the squirrel does not say to himself "beechnut for breakfast, hazelnut for lunch, acorn for dinner". He does not analyse and classify.

The reader coming to the library is in search of information. But, as a rule, it is not just *any* information. It is *particular* information. But since, by definition, he lacks this information how can he know what to look for? How can he define what he does not know? An interesting point emerges here. The less he already knows, the less he is able to specify what he does not know. The scholar who knows a great deal can specify very precisely the further information which he needs to complete some gap in his knowledge. The beginner who knows very little does not know what there is to know. Here we are evidently using the word "to know" in two distinct

senses. In the one sense it means "to have a clue". In the other sense it means "to have a grasp".

Even the squirrel has clues. He knows what a nut looks like, feels like, smells like and as he snuffles round he is following these clues. Without them he would fail to discriminate between nuts, stones, dead leaves, twigs or anything else. Thus retrieval depends on clues. Retrieval in a library is not merely a matter of physically removing a book from a shelf. It is a co-operative process in which the reader himself plays an essential part. It is his *partial* knowledge which supplies the clues. It is the business of the librarian to connect up these clues with the books on the shelves. But the system must not depend on the librarian's limited and fallible memory. True, in a small library, when a reader asks for something, say, on Roman coins, the librarian may remember the exact shelf where he recently placed a book on Archaeology containing just the information needed. But in a large library with many assistants and thousands of books this method of direct recall won't work. The library has to function "unconsciously", i.e. automatically. The clue must lead to the book even when the assistant has never seen the book. What then is the role of the assistant? How does he combine his ignorance with the ignorance of the reader to produce knowledge? This miracle is performed countless times every day and those who perform it scarcely stop to think how remarkable is the feat.

What is a clue? In a detective thriller it may take the form of a piece of mud on a carpet. There is plenty of mud in the world but most of it is not thought of as offering clues. What makes this particular piece a clue?

If the whole carpet were covered in muddy patches and the path in front of the house were muddy, and if it were known that a lot of people had been in and out, then no significance would attach to any particular piece. In a muddy room you expect to find mud. One particular piece tells us little or nothing. In other words the more probable a fact is the less it tells us. This is why probability plays such an essential role in modern Information Theory. The more *exceptional* a fact is, the more information it conveys. It is the mud on the otherwise spotless carpet that attracts our attention and demands an explanation. It points to a number of possibilities and opens up a whole field of inquiry.

So the first point about a valuable clue is that it is exceptional. The second point is that it conveys information because of its *position*. Mud on a path tells us nothing, but mud on a clean carpet tells us that someone probably carried it there on his shoe. And if the mud, when analysed, turns out to be different from the mud on the path but identical with the mud in another garden down the road (perhaps because of some fertiliser used in that garden and used by no one else in that road) the detective feels that he is on to something promising. The third point is that the significance of the clue depends on the knowledge which the detective brings to its interpretation. This was the fascination of Sherlock Holmes. His mind was so well-informed that trivialities acquired vital significance. To Dr. Watson they were meaningless. And the fourth point is that if it is a genuine clue it has some connection with the culprit.

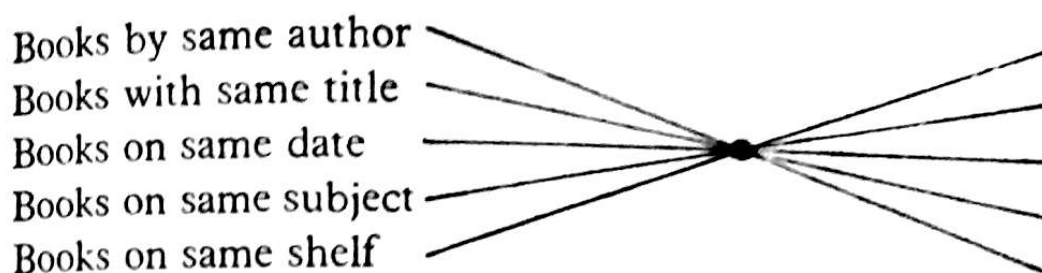
Here, then, in brief, is the theory of clues. (1) They are exceptional. (2) They have position. (3) They

require interpretation. (4) They lead to a certain destination. Librarianship is the systematic application of this theory. But whereas in crime the culprit involuntarily leaves clues, and the clues may be infinitely varied—mud, hair, cigarette-ends, scratches, finger-prints and all the rest—in the library clues are deliberately provided, and they are all of the same type. The library clues are cards in a box.

Let us then examine how the card-index of a library exemplifies the theory of clues, and leads the reader to the book he wants. To give an adequate account of this would require a whole book—*Teach Yourself Documentation*. All we can do here is to show that cards are clues and to suggest that the organisation of books in a library bears some analogy to the organisation of knowledge in the brain.

A library-card stating the author, the title, the date, the subject and the shelf on which the book is stored presents us with five different *types* of information. Each type will in general have other instances. The same author may have written a number of books. Many other books will have the same date. A few other books may even have the same title. Many other books may have been written on the same subject. Dozens of other books will be on the same shelf. If we could place all the books by the same author in a row on the floor, all the books bearing the same date also in a row, all books with the same title in another row, all books on the same subject in yet another row and finally all the books on that shelf in one more row, then the particular book we are concerned with would have to appear in all five rows. If there is only one copy then the only way to achieve this

is to allow all five rows to intersect. Our particular book is then at the point of intersection: thus



These five lines constitute a mathematical space of five dimensions. We cannot show this space on a flat page but we can show a single point in it as above. This point contains the information on the library-card. All the other cards are represented by unique points in this five-dimensional space.

When we consider the *subject* of the book we find that most subjects are complex, they have many branches and they overlap a great deal. This is the major problem of librarianship. The subjects need a multi-dimensional space of their own and the problem is to draw up a list of dimensions on which all the authorities can agree. These "dimensions" represent ways of classifying items of knowledge. Every brain has its own habitual system of classification, some more systematic than others. A great deal of the art of learning consists in regularising one's habits of classification. The more regular one's system the more mathematical is one's own "subject-space" and the more smoothly and economically it can absorb new information. The solitary learner can benefit himself enormously by habitually using a good library, not merely for borrowing books but in order to acquaint himself with the classification of knowledge. For this

is the library's business, and if the reader cultivates the acquaintance of the librarians, who are usually very friendly people, devoted to their work and very glad to discuss it, his own mental organisation will benefit by leaps and bounds. But to profit fully by this opportunity he needs to be exploring the dimensions of knowledge for himself and so discover the true meaning of organisation.

Organisation is the key to learning, to knowing and to remembering. The child on entering school enters on a life of organisation. The classroom arrangement, whether formal or apparently informal, organises his movements and living-space, and so too does the whole school architecture. The time-table organises his activities. The materials, pictures, books and other apparatus organise his stream of perceptions. The teacher and the other children organise his attitudes and his social consciousness. The pattern and rhythm of all this organisation go on throughout his educational career. The curriculum and the examinations organise his intellectual processes. Unfortunately the better the organisation the less equipped he is, on leaving school, to undertake the organisation of his own life.

Part, at least, of the stress of adolescence arises from the fact that it approximately coincides with the ending of a long period of organised existence and the beginning of a period in which new patterns and rhythms have to be established. The whole personality goes through a phase of disorganisation. As the body too, at this time, is reorganising itself to take account of a new and disturbing system of internal secretions from the rapidly developing sex glands, and the whole pattern of social

relations is taking on a new look, it is not surprising that home-life at this time is often stormy. For of course the fundamental need of each individual, just because he is an individual, is to organise himself. The ending of the constraints of school organisation gives him an intoxicating sense of freedom, but his lack of preparation for it also makes this freedom frightening. All kinds of people and institutions converge on him to take a hand in reorganising his life for him.

It is in this situation that books are so indispensable and such a series as "Teach Yourself" is of particular significance. For reading is a process of self-discovery as well as a pathway to knowledge. The adolescent cannot escape reorganisation. Whether he goes into the Forces, or industry, or commerce, or on to school or university, he has to come to terms with civilisation—unless he tries to contract out by defying the law, in which case, sooner or later, he finds that the organisation of law-enforcement may remove his freedom altogether.

Books are the gentlest and most accommodating of reorganisers. The reader can reorganise his mind at his own pace and on his own terms. But he must learn to organise his reading—not merely in the sense of selecting books in a purposive way, but in handling the growing body of knowledge in his own mind. The fact that the greater part of his book-knowledge is acquired and stored through the medium of language creates a special problem. For knowledge has many dimensions and language has only a single dimension. It is either a sequence of sounds in time or a sequence of signs on a line. And reading is a process that ploughs steadily on along the time-dimension.

The art of learning, remembering and knowing (which are not three distinct processes but three aspects of mental growth) is the art of reorganising information from books so that it is no longer spread out in time but made simultaneously available in space. The brain is a spatial structure and although the intake of information is a process taking time the information itself is stored in the space of the brain. Each item of information contains a multitude of clues which link it to other items. These links need not form one-dimensional chains but can be organised into networks. The brain has an insistent tendency towards organisation and, if left to itself, will pull together the most scrappy and disorganised material into some sort of pattern. Given a book to read right through, and given freedom from other distractions it will tend to hold, to interpret, to develop and to unify the contents of the book in its own way. The trouble for most of us is that the demands of daily life don't give our brains a chance to show what they really can do. The reading of a book may be spread out over weeks and during that time dozens of other experiences are being handled by the brain. The organisation which the brain is trying to impose on the contents of the book is continually interrupted. It is like trying to build a card house in a gale.

The remedy is to be found by *externalising* the organisation of the brain. By this I mean that during each reading-session the reader should try to draw a chart to show how the various items in the chapter connect themselves together in his brain. This is better than merely making notes. In effect it detaches part of his mind, puts it into cold storage and preserves it intact

until the next reading-session. He can then start where he left off—not only in the book but in his mind. The chart may be quite crude and tentative. The sequence of charts, as the reading progresses, will signalise the organising process through which his understanding grows and will themselves stimulate its growth.

To those who are unpractised in drawing charts this will at first seem a difficult and artificial process. It amounts to learning a new language, a language in two dimensions, having breadth as well as length. In a paper read at the International Conference on Scientific Information at Washington in 1958 I described this as the language of Semantic Matrices, and outlined its grammatical principles (Proceedings of the International Conference on Scientific Information, Washington, 1958. Published by National Academy of Sciences and National Research Council, 1959). Essentially it is the language of diagrams and graphs. It is a language of great power and freedom and can be learnt better from practice than from principles. It is not an alternative to verbal language but complementary to it. Its forms are endlessly varied and as it is freely used throughout the "Teach Yourself" series I cannot do better than to take examples from other books in the series to illustrate the principles of this language of mental organisation.

TEN

THE GRAPHIC LANGUAGE OF ORGANISATION

“NOWHERE, I believe, has more spectacular progress been made in the last few decades than in the investigation of the filing systems of the mind.”

E. H. GOMBRICH, Art and Illusion

TEN

THE GRAPHIC LANGUAGE OF ORGANISATION

To organise is to select things, to relate them together and to arrange them into a system. Graphic organisation requires an additional step, viz. *translation*. The facts or ideas to be organised must first be symbolised. And since the symbols must be understood they must either belong to some known language or code or must be semi-pictorial so as to carry their meaning visibly. One of the factors which makes graphic organisation so powerful is that it can draw simultaneously on a number of different codes and so achieve great economy of expression.

It is profitable to examine a number of charts and diagrams in some detail in order to understand their symbolism. Some codes are more obvious than others. Some are so little obvious as to be invisible. The most important example of this tacit symbolism is the relative positions of the elements in a diagram. The centre, the top, the bottom, the sides, the proximity or distance of

elements, all these can and should signify important relations.

Whether or not the reader is interested in any of the subjects represented in the ten examples given here he can still learn something from each concerning the endless flexibility and power of graphic expression. The two-dimensional grammar of a chart enables us to display relations between different elements of meaning, relations which have to be left implicit when the same information is presented as a string of sentences. The additional dimension does not merely double the amount of information that can be conveyed. It reveals a whole fund of information unsuspected when language is tied to a single dimension.

Teach Yourself Geology, by A. Raistrick.

Page 12. The Branches of Geology.

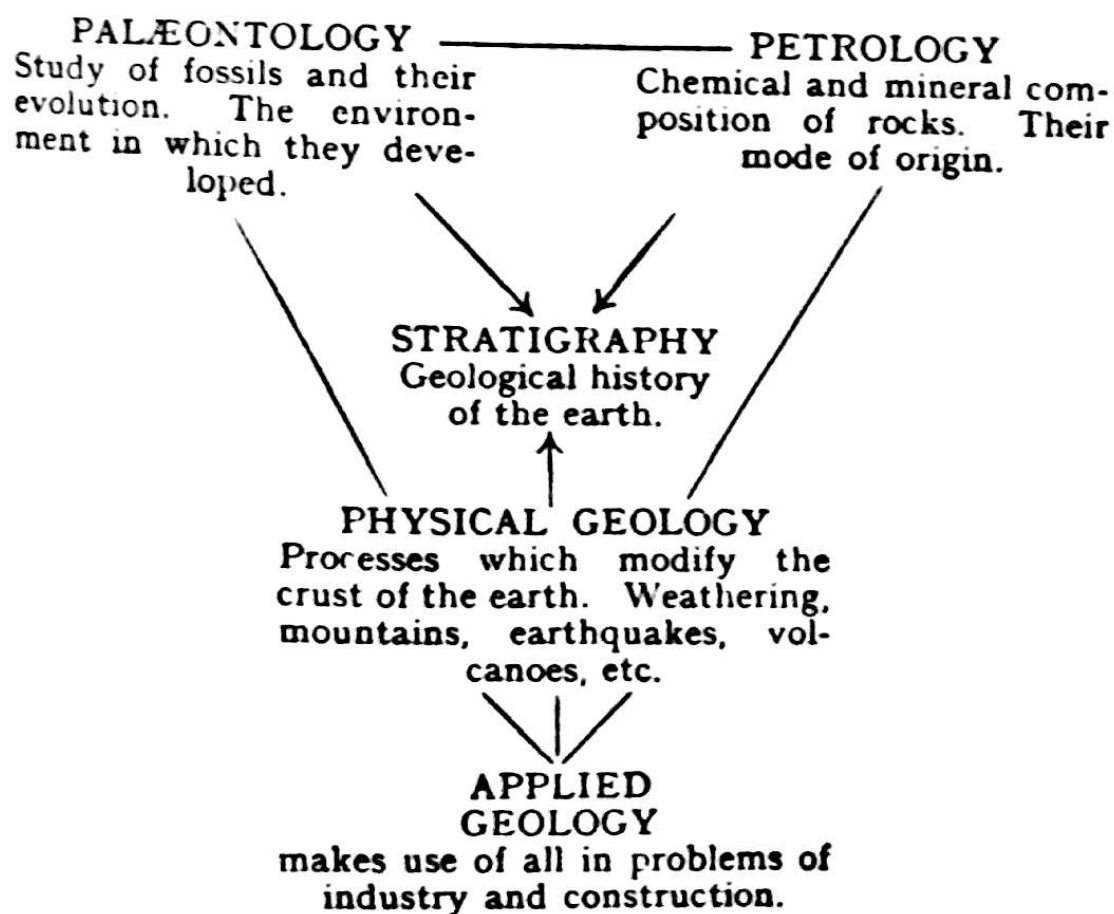
This is a simple chart but it is typical of an important class of charts. To organise one's knowledge is to treat it systematically. You cannot always arrange the learning process so that new knowledge is acquired in a systematic order—indeed if you are hungry for knowledge you should always seize what comes your way when it comes.

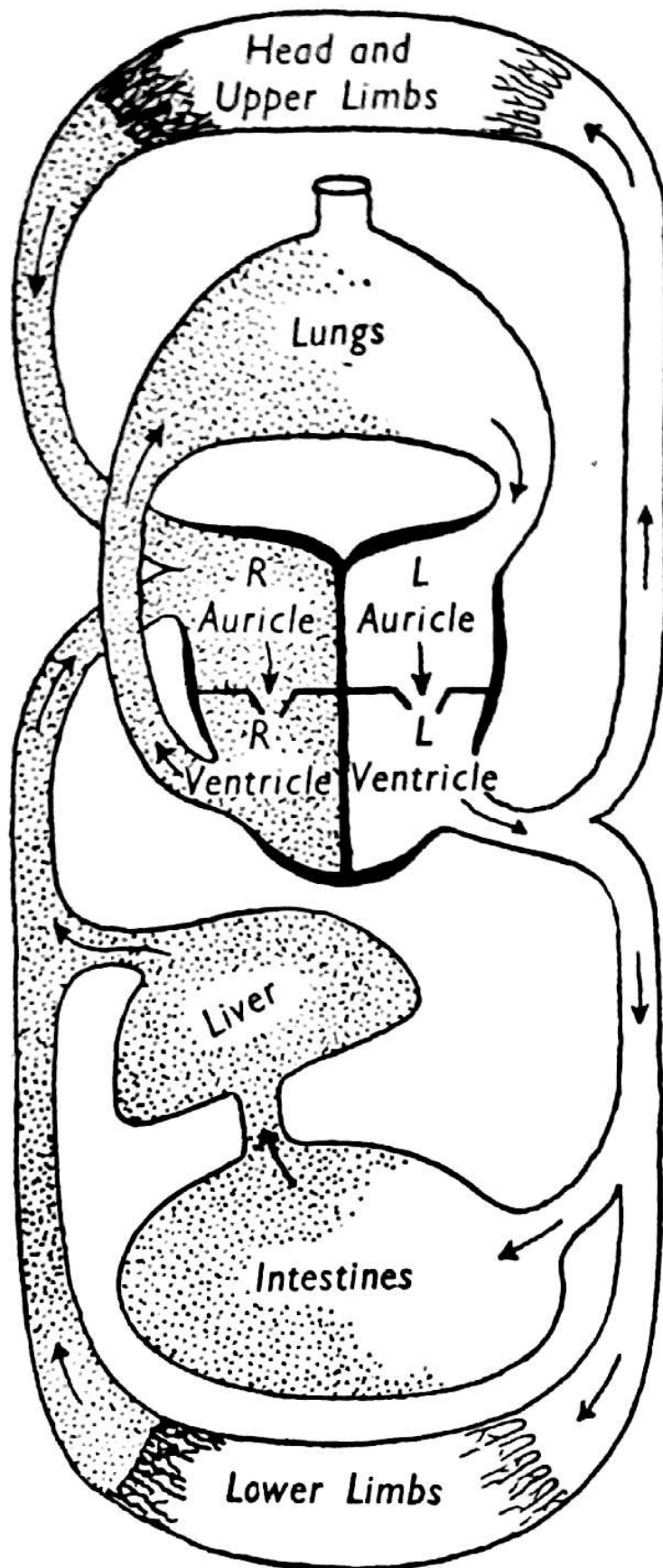
The organisation should be in the memory-store rather than in the learning. But this means having a plan so that whatever comes along has a place in the plan. Such charts as this one on the divisions of Geology enable us to classify different kinds of geological facts as they arrive.

Three great forces are continuously at work forming

and shaping the layers of the Earth's crust. These are (1) the physical forces of heat and cold, pressure and shock, water and friction; (2) the chemical forces of decomposition and synthesis; (3) the biological forces of life and death. The record of the past actions of these forces in the rocks give us Physical Geology, Petrology and Palæontology, respectively. Between them these combine to produce Stratigraphy in which the actual form and character of the rocks themselves are classified and organised. From this knowledge proceeds the practical application to mining, engineering and all the other fields of use.

The language of the chart is very straightforward—simply words and arrows. The triangular structure is expressive and easy to recall. Placed rightly near the





beginning of the book it serves as a guide to the whole subject.

Teach Yourself Anatomy, by A. D. Le Vay.

Page 26. Fig. 7.

A Diagram of the Circulation of the Blood.

This is a diagram in which the facts symbolised impose a certain natural arrangement in space. A highly schematic selection and representation of the parts of the body is drawn. It makes no attempt at realism because the object is not to show what the body looks like but how the flow of blood is distributed. Five codes are used.

1. Arrows to show the direction of flow.
2. Stippling to distinguish venous from arterial blood.
3. Letters R and L, for right and left
4. Words for parts of the body.
5. Relative spatial positions to show the relations between the parts.

There are nine main parts in this diagram—about the upper limit of what can be taken in virtually at a glance. After a few moments' study you should be able to reproduce it from memory. It organises centuries of anatomical and physiological research.

Teach Yourself Astronomy, by David S. Evans.

Page 14. Fig. 9 (see also Figs. 10–19).

This is a remarkable piece of organised knowledge

established many centuries ago from pure observation. It is the Celestial Sphere, an imaginary spherical framework (once believed to be real and made of crystal). The observer is seen at the centre but we, who are organising what he sees, are standing beyond the sky itself, outside the celestial sphere. We see his horizon, the celestial equator (the projection of the Earth's equator on the sky) and the circular paths traced by three different stars. The codes used are letters for various important positions; numbers for stars; straight lines for the

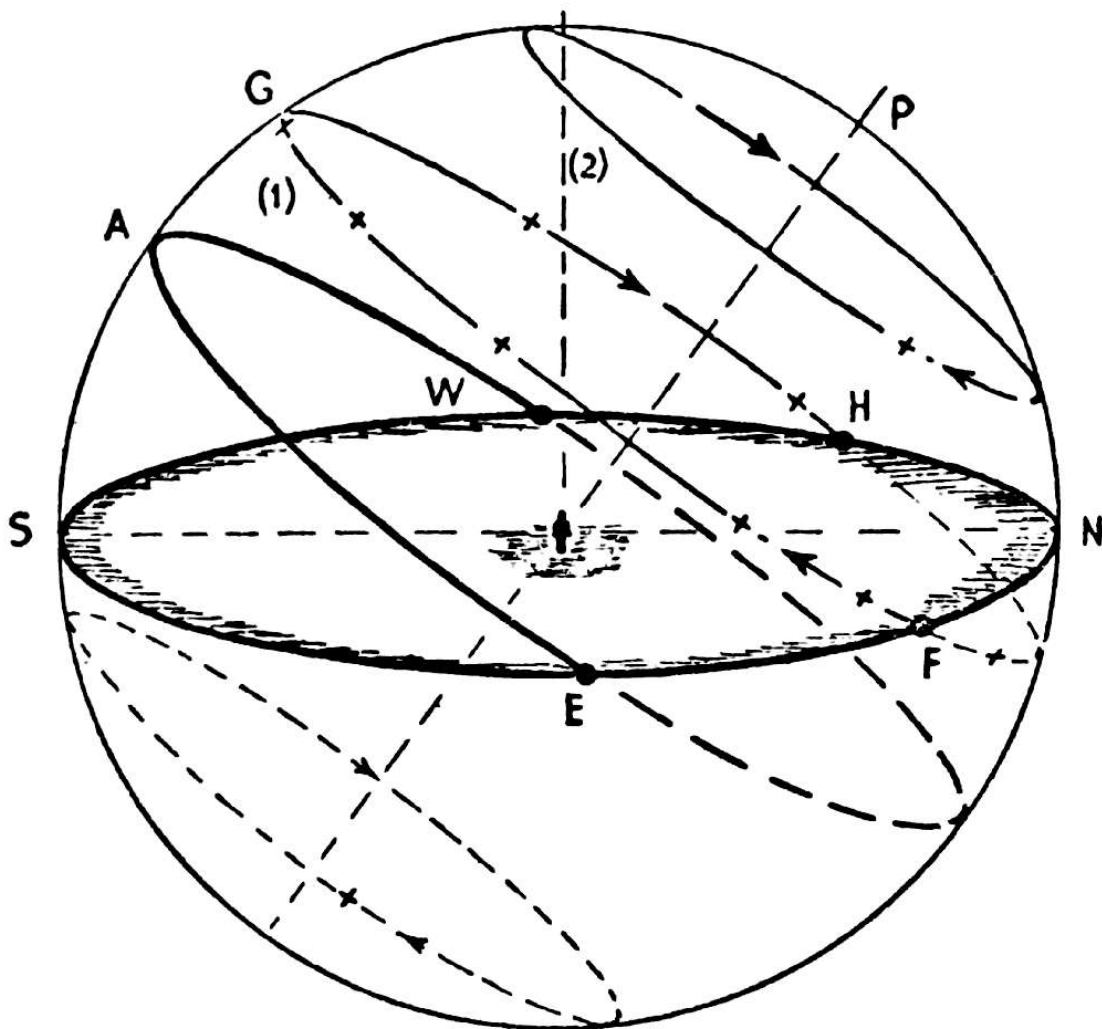


Figure 9

Star (1) rises at F, sets at H; Star (2) is circumpolar. P is the North Celestial Pole; EAW the Celestial Equator.

vertical, the north-south horizontal and the polar axis; ellipses for the various circles seen in perspective; a circle for the meridian; arrows for the direction of revolution of stars; shading to distinguish the earth's horizon, which is real, from the other circles which are abstract; and the little man at the centre to show whose point of view is being represented. The diagram invites you to imagine how the various circles would appear to him from the inside. Those circles sum up countless thousands of observations.

Teach Yourself Astronomy, by David S. Evans.

Page 61. Table of the Planets (see next page).

This is typical of many tables of scientific information in which innumerable measurements are summed up and systematically displayed. The planets are arranged in order of their distance from the sun, down the table. Their metrical properties, in arbitrary order, are displayed across the table. Three codes are used, viz. words, numbers and names of units.

Such a table not only presents detailed information about individual planets. It also enables numerous comparisons to be made. And it reveals systematic correlations. We see that as distance from the sun increases the orbital period consistently increases and the orbital velocity consistently decreases. The diameter increases from Mercury to Jupiter (with the notable exception of Mars) and then decreases consistently down to Pluto. The period of rotation seems to do the opposite, being the smallest for Jupiter. All this information is stored in a single compact arrangement.

The Planets

Name	Distance from Sun (millions of miles)	Distance from Sun (in astron. units)	Orbital Period (years)	Period of Rotation	Diameter (miles)	Velocity in orbit (miles per second)
Mercury	36.0	0.39	0.241 (= 88d)	? 88d	3,100	29.7
Venus	67.3	0.72	0.615 (= 225d)	? 30d	7,680	21.7
Earth	93.0	1.00	1.000	23h 56m	7,927 7,900 }	18.5
Mars	141.7	1.52	1.88	24h 37m	4,220	15.0
Jupiter	483.9	5.20	11.86	9h 50m	88,700 82,800 }	8.1
Saturn	887.2	9.54	29.46	10h 14m	75,100 67,200 }	6.0
Uranus	1784.0	19.19	84.02	10h 45m	31,800	4.2
Neptune	2797.0	30.07	164.8	15h 48m	27,800	3.4
Pluto	3670.0	39.60	247.7	?	3,600	2.9

Teach Yourself Biology, by M. E. Philips and L. E. Cox.
Page 173. Fig. 72.
A Classification of Living Things.

The progress of Biology has been intimately associated with the classification of living things. The amount of detailed information accumulated by the labour of naturalists over the centuries is prodigious. It would be quite impossible to absorb and to interpret without organisation. This table represents one of the simplest ways of displaying some of the fundamental differences between different groups of living things in a comprehensive way. Each of these great classes contains large numbers of different species but certain main features

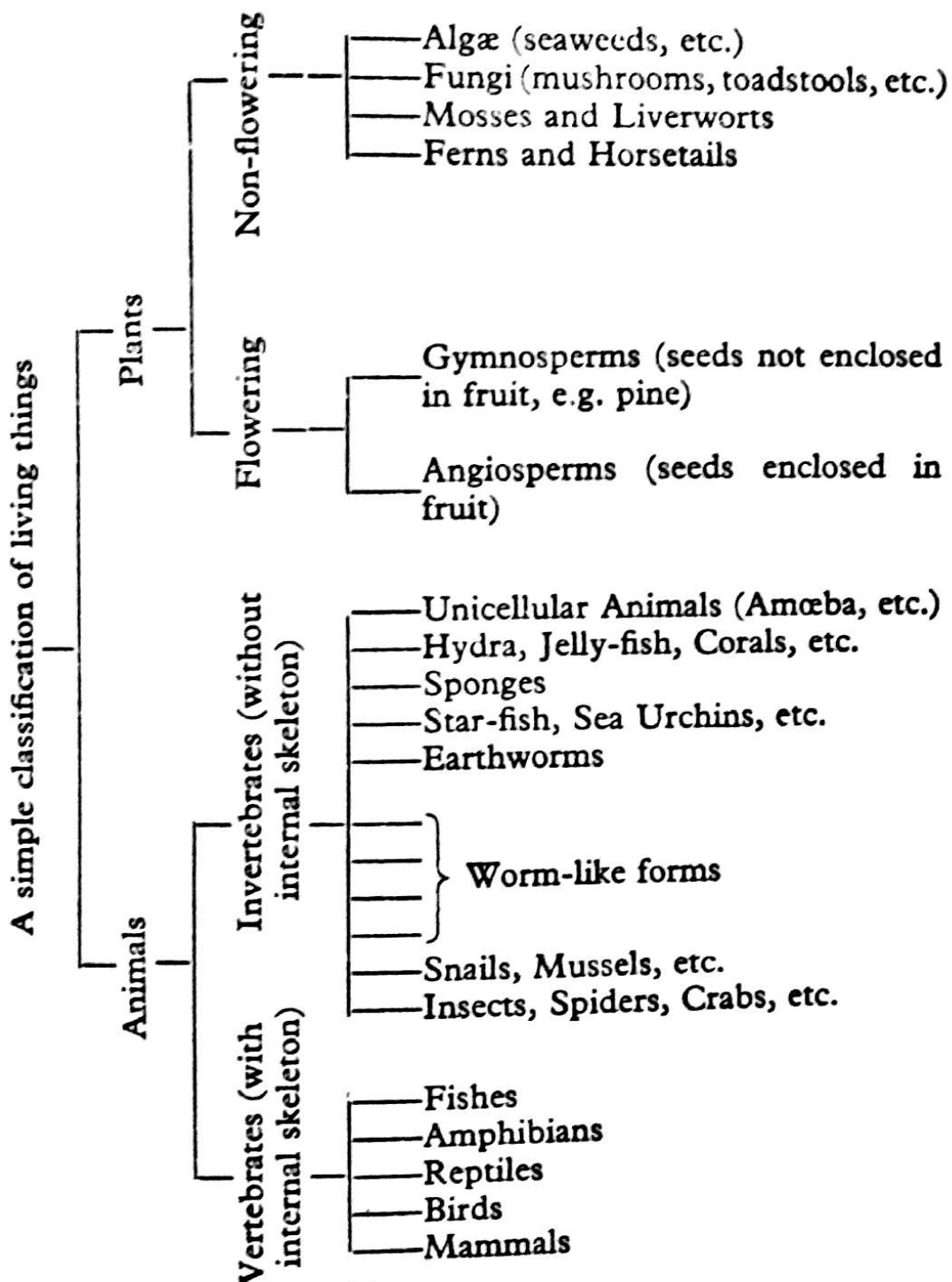


FIG. 72.

158 LEARNING, REMEMBERING AND KNOWING

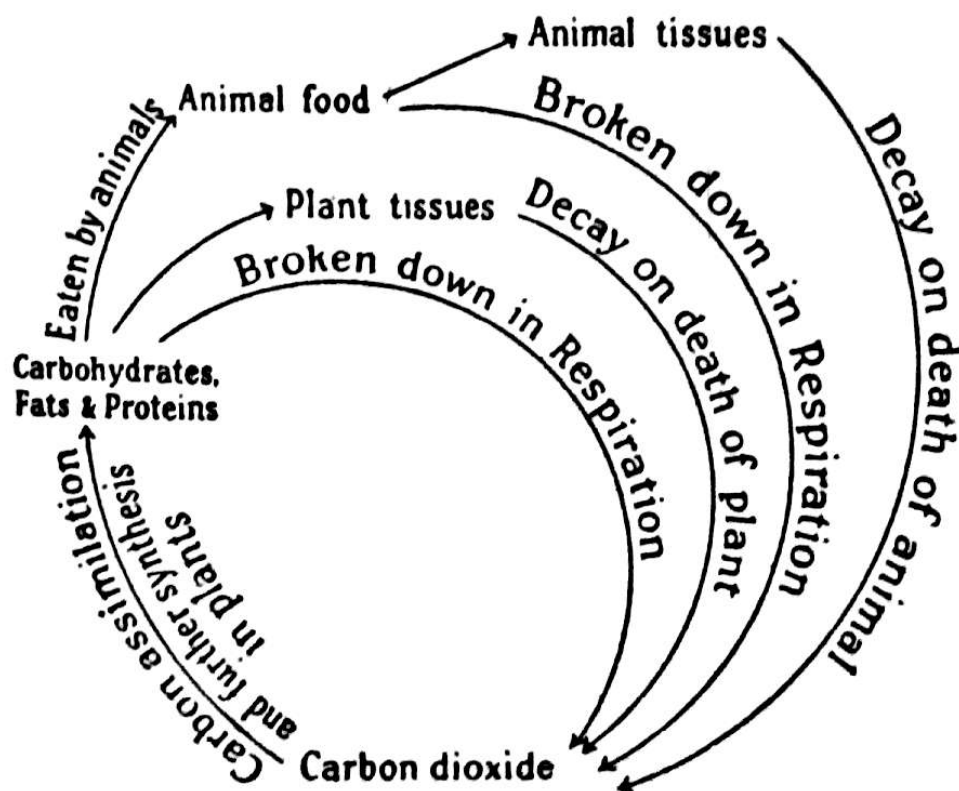
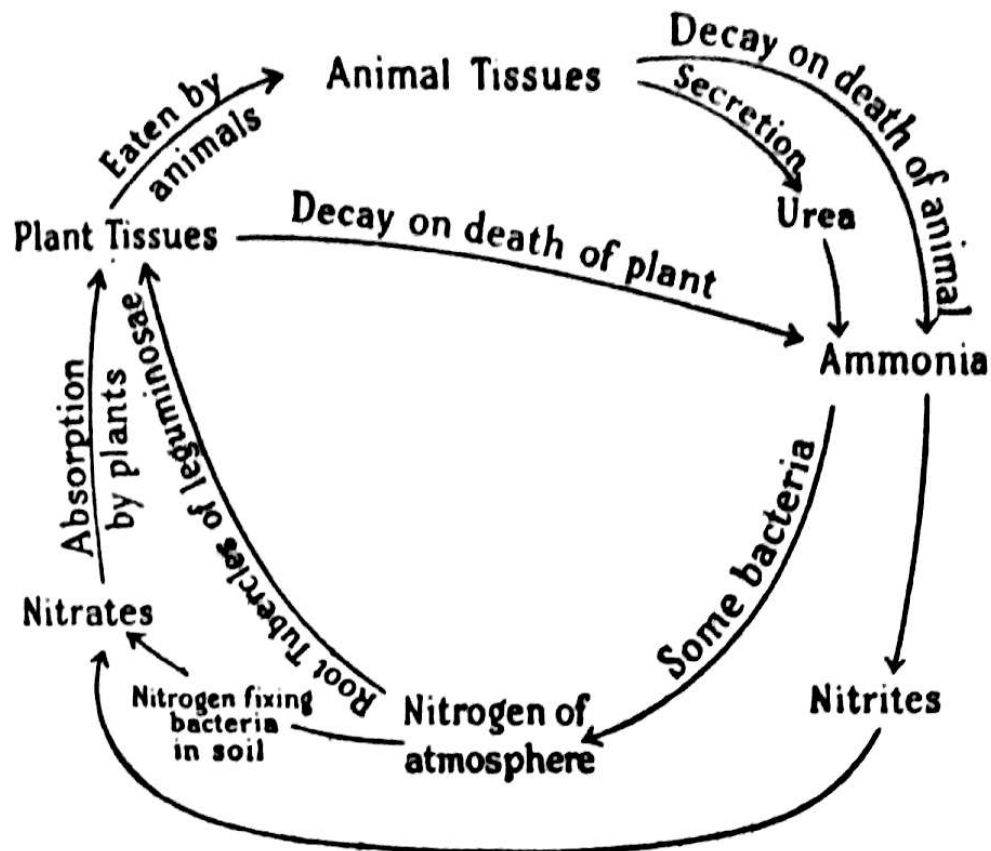
are possessed in common—a certain type of anatomy, a mode of breathing, a manner of reproduction, a relation to the environment. All this systematic knowledge is implicit in the table and gives it significance. Differences in the manner of reproduction run right through the table. It is reproduction which secures the continuation of each species. Each class or *phylum* may be regarded as a successful natural experiment in a different method of reproduction.

There are, of course, limits to what can be put on a single page. Each of the final divisions in this chart could be the starting point for a sub-classification. All these classificatory tables can look finished and dead. It requires an interrogative and imaginative eye to see through the printed arrangement to the underlying forms and activities of living creatures and to the changes imposed on them, over millions of years, by changes in land, air and water.

The language of the chart consists of words and lines only. The left-to-right direction represents the division of larger into smaller classes. By changing the orientation of the wording in the final, and most numerous, division the designer of the chart has been able to accommodate all the information in a clear and compact arrangement.

Teach Yourself Biology, by M. E. Philips and L. E. Cox.
Page 181. Figs. 75 and 76.
The Carbon and Nitrogen Cycles.

Here we have spatial arrangements of verbal information about highly complex bio-chemical processes. Almost literally such charts speak for themselves. The



curved lines suggest the persistent repetitions of Nature in making the same chemical elements serve the functions of life over and over again. The graphic organisation of the chart symbolises the chemical organisation of Nature.

All this information can, of course, be expressed in straightforward prose. But the graphic arrangement not only economises words—it yields far more insight. By a simple code of words and curved arrows the complex cycle of interaction between organisms, air and soil is brought to life.

Teach Yourself Chemistry, by G. Bruce MacAlpine.
Page 228. Mendeleev's Classification of the Elements.

This table is one of the most remarkable instances of graphic organisation of knowledge in the whole history of science. It demonstrated beyond doubt that the chemical elements form a single system of related families and thereby laid the foundations of modern atomic theory. Few chemistry books today bring out the tremendous intellectual excitement of this discovery—a discovery as far-reaching as that of Darwin, published ten years earlier. By following clues suggested previously by Döbereiner (1817, *Döbereiner's Triads*), and Newlands (1865, *Law of Octaves*), the great Russian scientist Mendeleev was able to arrange the known chemical elements in a system with empty places for elements yet to be discovered. Moreover from the regular way in which the properties of the known elements varied from one position in the table to the next he was able to predict the properties of the missing elements.

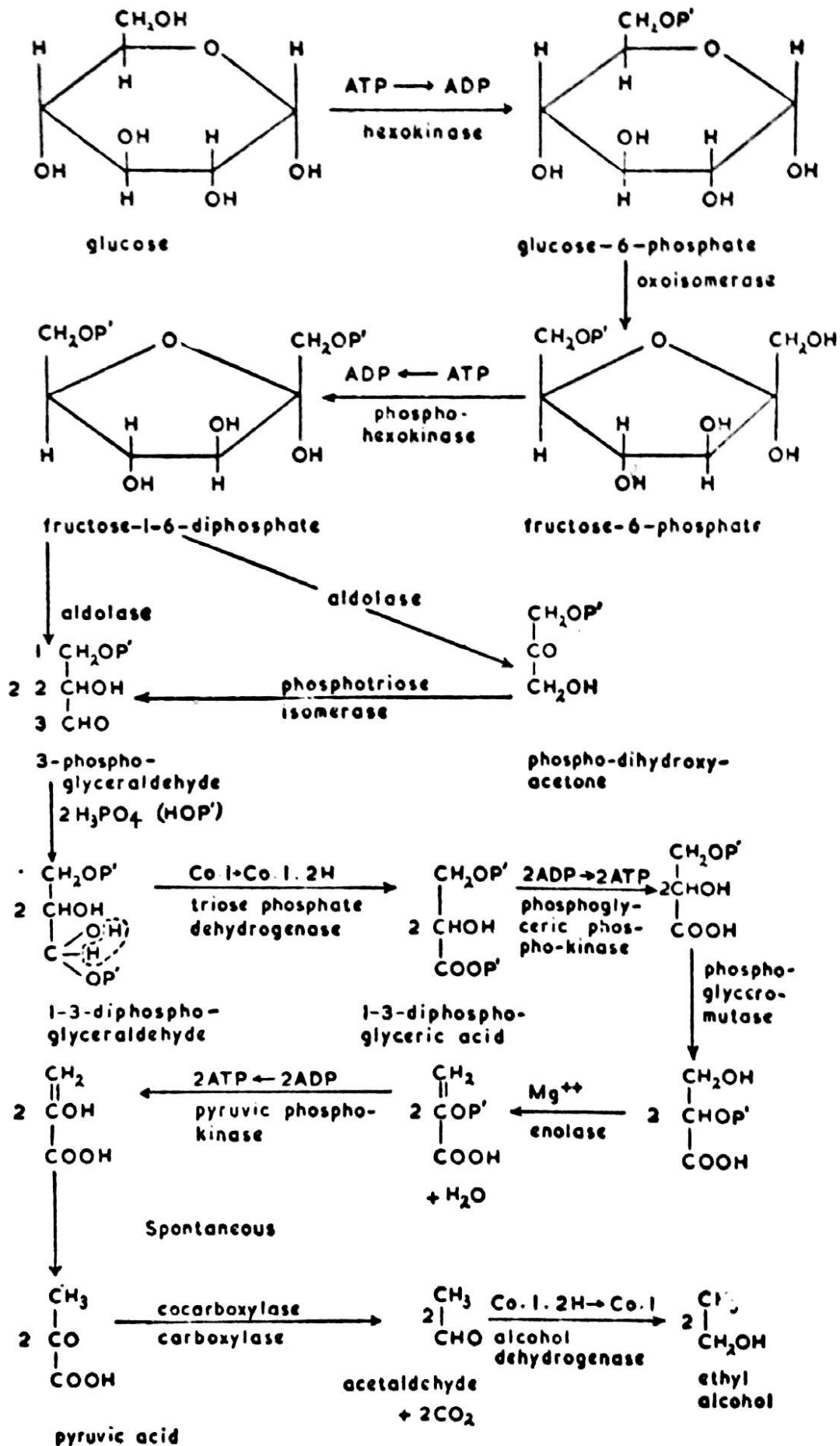
Row	Group I R_2O	Group II RO	Group III R_2O_3	Group IV RH_4/RO_2	Group V RH_3/R_2O_5	Group VI RH_2/RO_3	Group VII RH/R_2O_7	Group VIII RO_4
1	H							
2	Li	Be	B	C	N	O	F	
3	Na	Mg	Al	Si	P	S	Cl	
4	K	Ca	—*	Ti	V	Cr	Mn	Fe, Co, Ni, Cu.
5	(Cu)	Zn	—*	—*	As	Se	Br	
6	Rb	Sr	Yt	Zr	Nb	Mo	—	Ru, Rh, Pd, Ag.
7	(Ag)	Cd	In	Sn	Sb	Te	I	
8	Cs	Ba	Di	Ce	—	—	—	— —
9	—	—	—	—	—	—	—	
10	—	—	Er	La	Ta	W	—	Os, Ir, Pt, Au.
11	(Au)	Hg	Tl		Pb	Bi —	—	
12	—	—	—	Th	—	U	—	— —

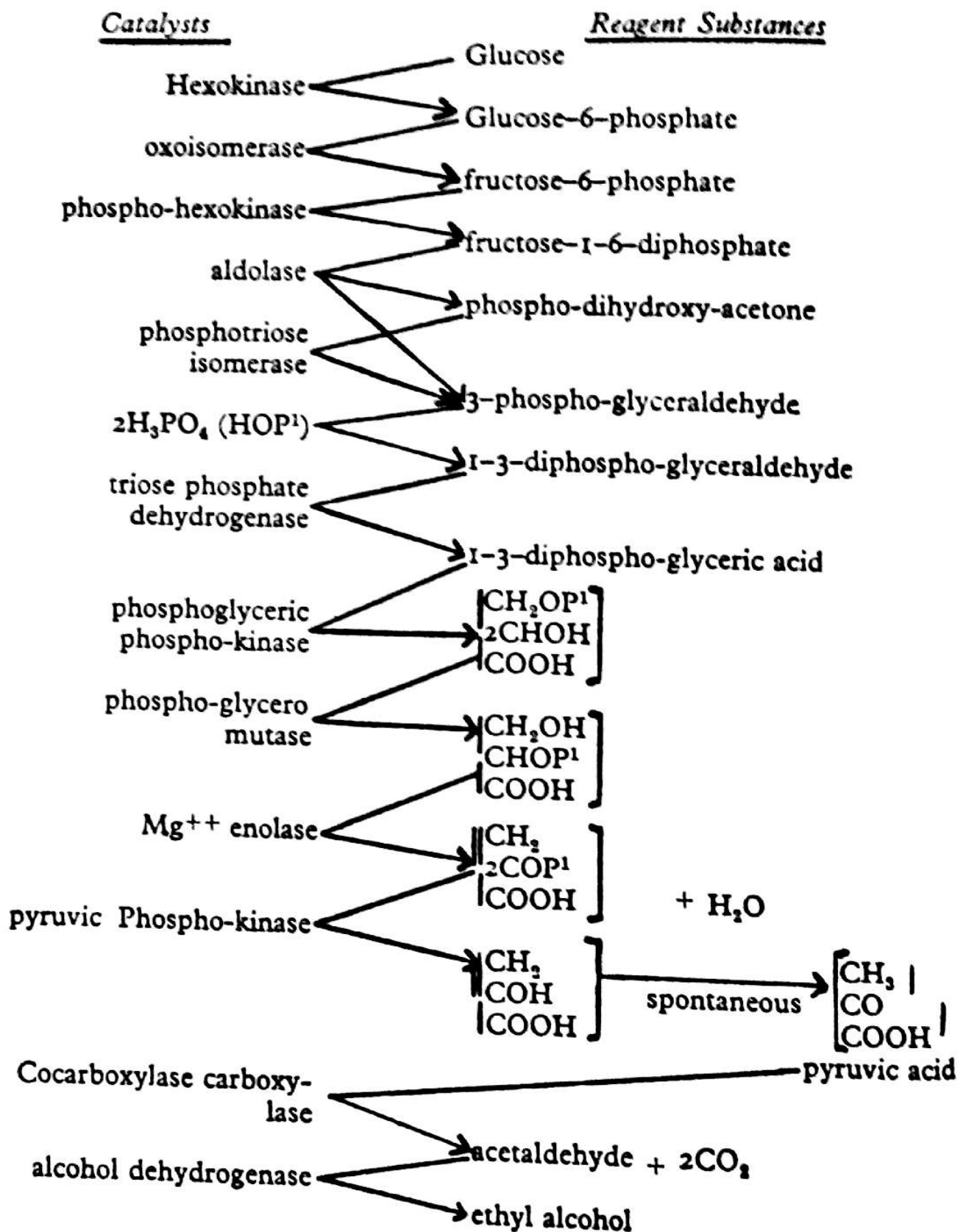
These elements were later discovered and his predictions fully confirmed. Thus the table shows the value of organising *incomplete* knowledge.

The spatial positions of both the elements and the gaps in this table symbolise relations between elements in a single family, going down the table, and between whole families, going across the table. Working through the whole table from left to right, row by row, we find the elements arranged in ascending order of atomic weight. It was Newland's discovery that every eighth element in the sequence, arranged in this way, bore a strong resemblance to its predecessor, in other words that properties showed a periodic recurrence, that led to the term "Periodic Table". The language of the table is the symbolic language of Chemistry guided by the invisible language of spatial relations, an impressive demonstration of the power of spatial order in organising our understanding.

Teach Yourself Biochemistry, by P. Jellinck.
Page 103. Alcoholic Fermentation.

Such a chart as this presupposes, of course, a thorough familiarity with the language of Chemistry. There are two levels of language in this chart and it might assist comprehension if a supplementary chart were drawn to distinguish the step-by-step sequence from substance to substance from the sequence of detailed substitution of radicles within the various molecules concerned. The skeleton of chemical change would then appear as in the chart below, in which the stages which are concertinaed for compactness in the original, are pulled out into a chain.





Teach Yourself Greek, by F. Kinchin Smith and T. W. Melliush.

Pages 236-7. The Numerals.

Books on language make extensive use of tabulation. The schoolboy groaning over his homework of declensions and conjugations seldom spares a grateful thought for the grammarians who, over the centuries, have quarried the mines of literature and, out of its endless variety and irregularity, discovered and preserved the laws and conventions by which usage is governed. Traditionally the tables embodying the outcome of their labours have formed the basis of language-teaching. They certainly ease the task of the teacher and examiner. Whether, as commonly used, they provide the speediest path to *learning* is an open question. Writers of language-texts take all kinds of liberties with the traditional arrangements and interweave exercises and expositions with the tables. Controversy on the principles of language-teaching is loud and persistent. The student needs not only to pass examinations but to read, write, speak and understand the language. Grammatical tables are but one means to these four ends, all of which are very different. The fact is that the learning of any language is a massive task and the most efficient way to organise the necessary mental effort is by no means obvious—nor need it be the same for different individuals. Opportunity and circumstance play decisive parts in the process. A visit to the homeland of the language is a great stimulus. A prolonged visit will, for most, provide a working mastery of the language with the least effort. But for many of us (and of course for dead

		Declension of First Four Cardinals.			
		εἰκοστος etc.	εἰκοσakis etc.		
20 εἰκοσι	—	εἰκοστος	εἰκοσakis	N. εἰς	μία ἐν
30 τριακοντα	—	τριακοστος	τριακοσakis	A. ἑνα	μῖαν ἐν
40 τεσσαρακοντα	—	τεσσαρακοστος	τεσσαρακοσakis	G. ἑνος	μίας ἐνός
50 πεντηκοντα	Pentecost	πεντηκοστος	πεντηκοσakis	D. ἐνι	μῖα ἐνι
60 ἑξηκοντα	—	etc.			
70 ἑβδομηκοντα	—				
80 ὀγδοηκοντα	—				
90 ἐνενηκοντα	—				
100 ἑκατον	hecatomb				
200 διακοσιοι, -αι, -α	—			N. } δυο	
300 τριακοσιοι, -αι, -α, etc.	—			A. } δυοιν	
1,000 χιλιο, -αι, -α	kilo, kilo-metre			G. } τρεις	τρια
2,000 διςχιλιοι	—			D. } τριων	τριων
10,000 μυριοι	myriad				τρισι
100,000 δεκα μυριαδες	—		μυριακis	N. τετταρες	τετταρα
				A. τετταρας	τετταρα
				G. τετταρων	τετταρων
				D. τετταραι	τετταραι

	Cardinals.	Derivatives.	Ordinals.	Adverbs.	Derivatives.
1	εἷς, μιά, ἐν	—	πρῶτος	ἀπᾶξ (once)	Deuteronomy (νομός)
2	δυο	dual	δευτερος	δύς	
3	τρεις, τρια	tripod	τρίτος	τρίς	
4	τετταρες, τετταρας, (or τεσσαρες)	tetrarch,	τετάρτος	τετράκις	
5	πεντε	tessellated pentagon, pentameter	πέμπτος	πεντάκις	hebdomadal (weekly)
6	ἑξ	hexagon, hexameter	ἕκτος	ἑξάκις	
7	ἑπτα	heptarchy	ἑβδομος	ἑπτάκις	
8	ὀκτω	octopus	ὀγδοος	ὀκτάκις	
9	έννεα	—	έννατος	έννάκις	
10	δεκα	decalogue, decade	δεκάτος	δεκάκις	
11	ένδεκα	hendeca- syllables	ένδεκατος	ένδεκακις	
12	δωδεκα	Dodecanese	δωδεκάτος	δωδεκακις	
13	δεκα, etc. τρεις και	— —	τρίτος και δεκάτος	τρίς και δεκάκις	

languages) it is a matter of books and concentration. The tables break up the task into manageable chunks. It is an artificial method but, given steady and sustained effort, it works. Tables such as the one exemplified here, in which systematic derivatives and mnemonic clues are provided, can cover important areas of language in an economical and helpful way. But there are two important principles in the use of such tables. The first is that of extensive application of the material in the table in a variety of contexts. The second is the principle of intensive concentration. When learning a language it is best, if possible, to make it your major interest for a few months, so that whatever is learnt is kept active for long enough to knit up. Tables are means to an end, like scaffolding.

Teach Yourself French

Page 49. Table of Terminations of Regular Verbs.

We do not normally think of applying mathematics to a natural language like French. Yet a systematic table like this one does have something mathematical about it. It can be regarded as a three-dimensional framework. The dimensions, viz. conjugation, person and tense, are not continuous lines but discontinuous *categories*. If each termination were written on a card the cards could all be placed in a system of boxes. Not counting the Imperative there are $6 \times 6 \times 4$ terminations altogether, i.e. 144. Thus a three-dimensional framework 6 units long, 6 units high and 4 units wide, would accommodate all these cards.

By exploring the other dimensions of language we

are beginning to see that it possesses many mathematical features unsuspected by the grammarians. This is making possible the construction of machines which can translate from one language into another. These machines are important not only in saving human effort but in forcing on us a new understanding of language. With this we shall develop new and more economical methods of learning languages.

REVISION OF VERBS—NEGATION

TABLE OF TERMINATIONS OF REGULAR VERBS

CONJUGATION	I.	II.	III.	IV.
<i>Infinitive</i>	er	ir	evoir	re
<i>Present Participle</i>	ant	issant	evant	ant
<i>Past Participle</i>	é	i	u	u
<i>Present</i>	e es e ons ez ent	is is it issons issez issent	ois ois oit evons evéz oivent	s s — ons ez ent
<i>Imperfect</i>	ais ais ait ions iez aient	issais issais issait issions issiez issaient	evais evais evait evions eviez evaient	ais ais ait ions iez aient
<i>Future</i>	erai eras era erons erez eront	irai iras ira irons irez iront	evrai evras evra evrons evrez evront	rai ras ra rons rez ront

REVISION OF VERBS—NEGATION (*continued*)

CONJUGATION	I.	II.	III.	IV.
<i>Conditional</i>	erai erai erait erions eriez eraient	irai irai irait irions iriez iraient	evrai evrai evrait evrions evriez evraient	rai rai rait rions riez raient
<i>Subjunctive Present</i>	e es e ions iez ent	isse isses isse issions issiez issent	oive oives oive evions eviez oivent	e es e ions iez ent
<i>Subjunctive Imperfect</i>	asse asses ât assions assiez assent	isse isses ît issions issiez issent	usse usses ût ussions ussiez ussent	isse isses ît issions issiez issent
<i>Imperative</i>	e ons ez	is issons issez	ois evons evez	s ons ez

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